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FIRST YEAR WORK PLAN for a TECHNOLOGY ASSESSMENT OF WESTERN ENERGY RESOURCE DEVELOPMENT

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EPA Review Notice

FOREWORD

This Work Plan for a Technology Assessment of energy development in the Western United States is one of the first products of the Integrated Assessment Program established by the Office of Energy, Minerals, and Industry (OEMI), U.S. Environmental Protection Agency (EPA). The Integrated Assessment Program was begun in response to recommendations of an interagency Task Force established by the Office of Management and Budget to examine the Federal research program in "Health and Environmental Effects of Energy Use." The Task Force concluded that the social and economic consequences of alternative energy and environmental policies needed to be considered in very close coordination with the examination of the health and environmental consequences of such policies. They recommended the formation of a research program to identify "environmentally, socially, and economically acceptable (energy development) alternatives" by integrating the results of socio-economic, health effects, and ecological impacts research (Report of the Interagency Work Group on Health and Environmental Effects of Energy Use, November, 1974, prepared for the Office of Management and Budget; Council on Environmental Quality, Executive Office of the President).

This report is an appropriate choice to inaugurate the Integrated Assessment Program. The purpose of any Technology Assessment is to place the development of a new technology, or the expansion of an existing technology into a new area, into a social/economic/political/cultural perspective.... to look beyond the primary effects of that technology to those "impacts that are unintended, indirect, and delayed" (Joseph Coates in The Futurist, December, 1971). This is clearly the intent, as described above, of the Interagency Task Force recommendation.

This report was prepared by the Science and Public Policy Program (S&PP) of the University of Oklahoma in Norman, and the Radian Corporation of Austin, Texas. The Project Director is Irvin L. (Jack) White, Assistant Director of S&PP and Professor of Political Science at the University. F. Scott LaGrone, Vice-President of Radian Corporation, is Assistant Project Director. The EPA Project Officer is Steven E. Plotkin of the Office of Energy, Minerals, and Industry.

The report presents a research plan for conducting a Technology Assessment of the development of coal, oil shale, oil, natural gas, geothermal and uranium resources in the Western United States. In the first year, the Assessment will focus on the impacts occurring within the States of Colorado, Utah, New Mexico, Arizona, Wyoming, Montana, and the Dakotas; will not attempt to explicitly model the impacts of "exogeneous" (imposed from the outside) variables, such as Gross National Product or national inflation rates, on the rate of energy development in the West; and will place some strong restrictions on the number of technological alternatives to be examined in depth, focusing on those that are most advanced or for other reasons most likely to affect the region in the mid-term (1985-2000).

The implication of these restrictions is that the Assessment is focusing, in the first year, on the question of how to cope with development if and when it occurs. The parallel questions that a "complete" Technology Assessment would attempt to answer - whether or not development should occur, and how to realize the level of development desired (or, at least, how to predict the level likely to occur) - require analyses considerably beyond the first-year study boundaries.

The question of whether or not development should occur requires an extensive analysis of two subjects:

1. How much energy, and in what forms, does the Nation actually require in the time frame of interest?

2. What are the alternative energy supplies outside of those in the West, and what are the consequences of developing them?

The alternative supply question cannot be fully answered until a whole series of Technology assessments encompassing these alternatives have been completed and integrated. This is a key long range goal of the Integrated Assessment Program.

The question of how to realize the level of development desired, or how to predict the level likely to occur, requires an understanding of supply and demand relationships and an ability to model them, that is beyond the resources of the study team. The Federal government has extensive efforts underway to develop the required models - the Project Independence models are the focus of much of this effort. If these models develop to the extent that they can be useful to this Assessment, they will be exercised.

Stephen J. Gage
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ABSTRACT

This report presents a Work Plan for conducting a Technology Assessment of energy resource development in the Western U.S. The energy resources addressed are coal, oil shale, oil, natural gas, geothermal, and uranium. The geographical focus is on the States of North and South Dakota, Montana, Wyoming, Utah, New Mexico, Arizona, and Colorado. The time frame to be addressed is the period 1975-2000. The Assessment is designed to identify and quantify the diverse impacts of energy development in the West, including secondary or higher order impacts. Further, the Assessment will identify and assess policy alternatives for dealing with these impacts, with a special focus on environmental protection strategies. Nine scenarios are used to structure the analysis. Six of these are site-specific: Kaiparowits/Escalante, Navajo (Farmington), Rifle, Gillette, Colstrip, and Beulah. Two are river basins: the Upper Colorado and the Upper Missouri. And one is comprised of the eight states within which much of the six energy resources are concentrated.

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ACRONYMS AND ABBREVIATIONS

bbl	barrels
BLM	Bureau of Land Management
BOD	biochemical oxygen demand
Btu	British thermal unit
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
CO	carbon monoxide
COD	chemical oxygen demand
dB	decibel
dBA	decibels A-weighted
EHV	extra high voltage
EIS	environmental impact statement
EPA	Environmental Protection Agency
ERDA	Energy Research and Development Administration
ERDS	energy resource development system
ERIS	Energy Research Information Service
FEA	Federal Energy Administration
hp	horsepower
HV	high-voltage
ICC	Interstate Commerce Commission
ITA	integrated technology assessment (used interchangeably with TA)
L_d	daytime equivalent sound level
L_{dn}	day-night equivalent sound level
L_{eq}	A-weighted equivalent sound level
L_n	nighttime equivalent sound level
LASL	Los Alamos Scientific Laboratory
MERES	Matrix of Environmental Residuals for Energy Systems
MESA	Mining Enforcement Safety Administration
mmcf	million cubic feet
mmscf	million standard cubic feet
MT	metric ton
Mw	megawatt
NASA	National Aeronautics and Space Administration
NIOSH	National Institute of Occupational Safety and Health
NOAA	National Oceanic and Atmospheric Administration
NO_x	nitrous oxides
NO_2	nitrogen dioxide

NSF	National Science Foundation
NSSP	New Source Standards of Performance
ONAC	EPA's Office of Noise Abatement and Control
OPEC	Organization of Petroleum Exporting Countries
OSHA	Occupational Safety and Health Act (or Administration)
PAN	Peroxyacyl Nitrates
PIES	Project Independence Environmental Statement
ppm	parts per million
S&PP	Science and Public Policy Program
SEAM	Surface Environment and Mining
SEAS	Strategic Environmental Assessment System
SO_2	sulfur dioxide
SRI	Stanford Research Institute
ss	suspended solids
TA	technology assessment (used interchangeably with ITA)
TDS	total dissolved solids
TLV	threshold limit value
TOSCO	The Oil Shale Corporation
UCRB	Upper Colorado River Basin
UMRB	Upper Missouri River Basin
USGS	U.S. Geological Survey
ZDP	Zero Discharge of Pollutants

ACKNOWLEDGMENTS

The authors wish to acknowledge the efforts of many individuals on the staffs of Radian and the Science and Public Policy (S&PP) Program who contributed substantially to this report.

The following members of the S&PP staff provided important technical support to this effort: Dr. Hee Man Bae, post-doctoral fellow; Timothy A. Hall, Joe Lee Rodgers, and Rodney Freed, graduate research assistants; and Martha T. Jordan and Nancy J. Creighton, research assistants.

The editorial/administrative staff of S&PP greatly assisted in the preparation of this draft. Janice K. Whinery directed logistics as project specialist; Peggy L. Neff coordinated preparation of manuscripts as clerical supervisor, and along with secretaries Sharon S. Pursel and Lou E. Malone, typed the numerous drafts of this manuscript. Mary Overstreet and her staff at Radian also assisted in the preparation of manuscripts.

A draft revision of this work plan dated October 31, 1975 was widely circulated to Federal agencies, State governments, industry, energy and environmental researchers, interest groups, and interested individuals. Persons receiving the draft were asked to examine it critically and to send us their comments and suggestions. A list of the names of persons who responded or who otherwise contributed to the development of this work plan is presented in Appendix A.

Responsibility for the contents of this report rests solely with the Science and Public Policy Program of the University of Oklahoma and Radian Corporation of Austin, Texas. Any errors are those of the research teams that prepared this report.

CHAPTER 1

FIRST YEAR WORK PLAN REPORT

1.1 INTRODUCTION

Given its substantial and diverse energy resources, the western U.S. is a prime regional candidate for increasing domestic energy production. Development of these resources will inevitably produce a broad range of economic, social, environmental, and institutional costs and benefits, not only locally, but nationally and internationally as well. Some of these will fall within the Environmental Protection Agency's (EPA) statutory responsibility for protecting the environment. This responsibility, together with a desire to integrate the results of other energy and environmental studies, has led EPA to sponsor a "Technology Assessment of Western Energy Resource Development". The Science and Public Policy Program (S&PP) of the University of Oklahoma, and Radian Corporation of Austin, Texas, outlined a study plan for this technology assessment (TA) in their "Technical Proposal" submitted in response to EPA's request for proposal.[1] This work plan report extends and clarifies the

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[1] Environmental Protection Agency (March 21, 1975) "Request for Proposal Number WA 75X-128."

first year study plan outlined by the S&PP-Radian team in their proposal and subsequent "Draft First Year Work Plan Report."[1]

1.2 PURPOSE AND SCOPE

The overall purpose of this technology assessment is to determine the likely consequences of various patterns, rates, and levels of development of western energy resources, and to suggest how desirable consequences can be encouraged and undesirable consequences either eliminated or mitigated. In short, this is a policy-oriented technology assessment undertaken to provide more and better information about the consequences of development for all persons participating in making western energy resource development policies, particularly those who make and implement environmental protection policies.

For western energy resource development policies to be thoroughly informed, the full range of costs and benefits resulting from development need to be identified and assessed. While this study is intended to identify and assess a broad range of consequences, it cannot be comprehensive. There are several reasons for limiting the scope: first, research resources are limited; second, existing knowledge about impacts is deficient;

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[1]University of Oklahoma, Science and Public Policy Program and Radian Corporation (October 31, 1975) Draft First Year Work Plan Report for a Technology Assessment of Western Energy Resource Development. Norman, Ok.: University of Oklahoma, Science and Public Policy Program.

third, data are inadequate; and fourth, the requisite analytical tools are not available.

As the project title indicates, this effort is limited spatially to the western U.S. We define this region on the basis of the location of large quantities of energy resources and where it appears that large scale energy developments are most likely to be undertaken. Emphasis will be placed on the Rocky Mountain and Northern Great Plains states: Arizona, Colorado, Montana, New Mexico, North Dakota, South Dakota, Utah, and Wyoming (see Figure 1-1). The procedures used in arriving at this spatial delimitation are explained in Chapter 3. It should be noted here that the goal is to assess developments in areas and at specific sites in the West which include unique as well as representative conditions.

The study will not emphasize the analysis of forces external to the region which tend either to drive or forestall development of western energy resources. Nor will any attempt be made to specify an optimum rate of development. These limitations in scope are imposed in full recognition of the importance of these factors; but they are either excluded or deemphasized because: (1) current national policy stresses the development of dmoestic energy resources, including those located in the western states; and (2) the primary planning needs of EPA, other federal agencies, and state and local officials are for information about the consequences of energy resource development and alternative policies for dealing with these consequences.

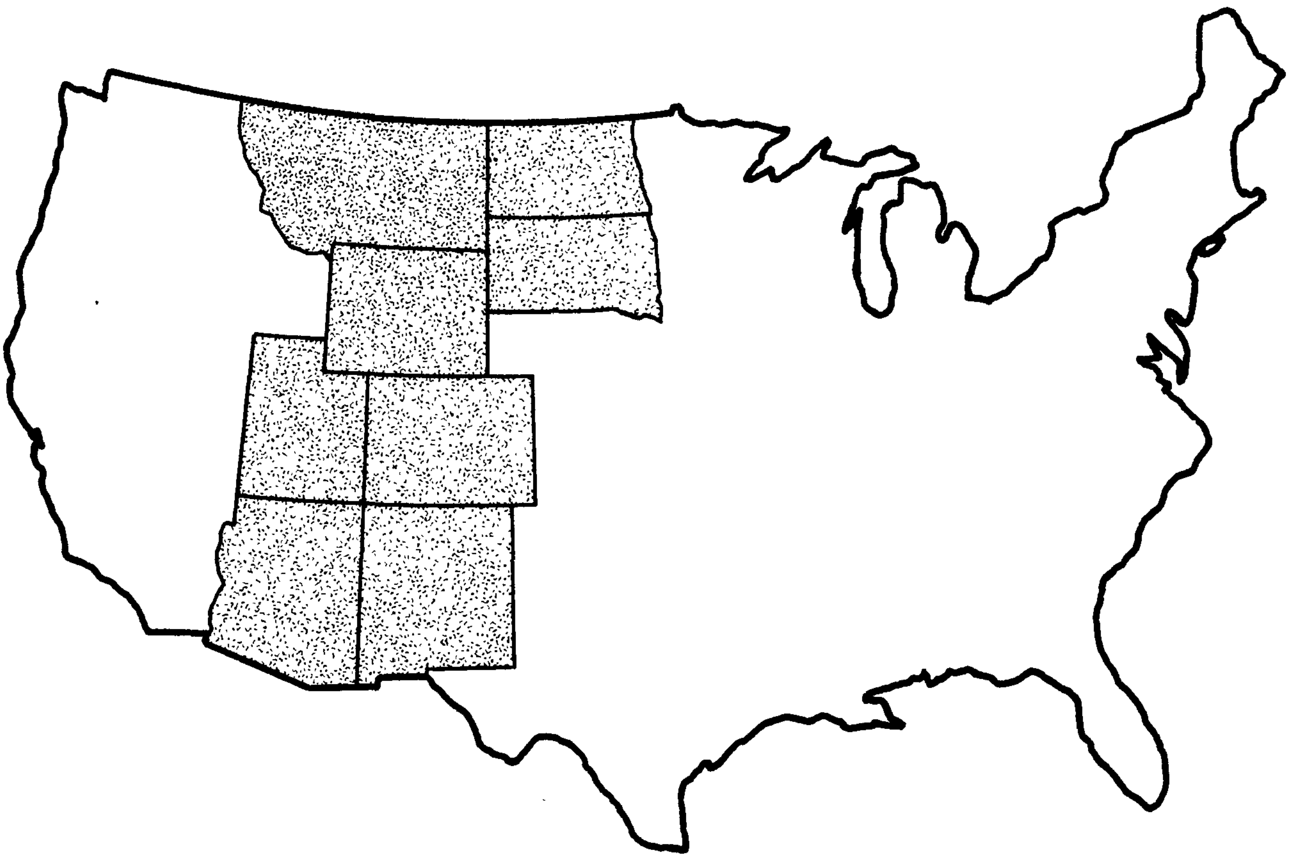

Figure 1-1: States Included in the Western Region

The energy resource developments to be assessed include coal, crude oil, natural gas, oil shale, uranium, and geothermal. It is anticipated that these resources, especially coal, will provide much of the new energy produced from the western states. More importantly, they are energy forms which can be readily exported to other regions of the country either as a raw resource or as a processed fuel and contribute to a national energy supply program. Given their importance to the nation's energy future, the spatial and temporal distribution of costs and benefits should be carefully assessed to inform public policies now being made and implemented concerning the development of these resources.

Tar sands and thorium are the principal minable energy resources that are excluded, tar sands because of its limited quantities and thorium because the development of reactors using thorium as a fuel is deemphasized by both industry and the Energy Research and Development Administration (ERDA). Solar power in its various forms is not explicitly analyzed, not to deny its potential contribution, but because: (1) anticipated uses before 2000 are local, rather than for export from the region; and (2) recent interfuel substitution models indicate limited utilization of solar in the foreseeable future.[1] For similar

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[1]Although solar energy development is not assessed, most of the energy models used to determine what quantities of energy in what fuel form will have to come out of the western states in 1990 and 2000, will take all energy forms into account. See Chapter 3.

reasons, utilization of energy from various kinds of organic wastes is not included in the assessment. Hydroelectric resources, although contributing substantial power in the West, have already been largely developed and, in the future, will contribute a diminishing share of western energy production.

Technological limitations, at least for the first year, include restrictions on the assessment of uranium and crude oil to exploration, extraction, and transportation technologies. If enrichment and reactor technologies were to be included, the scope of the project would be greatly expanded. Although there are several refineries in the area, relatively little refinery expansion or new grass roots facilities are planned, especially in comparison with other areas of the U.S. The scope of the assessment of both uranium and crude oil may be expanded in the second and third years.

Otherwise, a wide range of technological options, from exploration to transportation, will be included for the other five energy resources. The specific combinations of resources and technological alternatives to be assessed are identified in Chapter 3.

In keeping with the integrating character of technology assessment as a policy-informing research activity, data are to be drawn entirely from secondary sources. This limitation has been imposed, not only in recognition of available research resources, but also because one of EPA's reasons for funding this study is to determine where there are gaps in its research programs.

The time frame for the study is from 1975 to 2000. This overall time period is divided into three periods: 1975 to 1980, 1990, and 2000. It should be noted that this period includes the start-up and normal operation of energy facilities, but not, in most cases, the subsequent shutdown. Explicit attention will be given to the differences between construction and operation phases during the first year. The impacts associated with shutdown will be considered during the second and/or third years.

Although the scope of the assessment is limited as described above, its overall purpose will not be achieved if the concerns of the local, state, and federal governments, interstate and regional governmental organizations, industry, labor, Indians and other ethnic and minority groups, and other interested groups and individuals are not taken into account. Consequently, the assessment described in this work plan is designed to produce policy-informing results useful to those who have responsibilities for or an interest in the development of western energy resources.

1.3 SPECIFIC OBJECTIVES

Given the overall purpose and limitations in scope discussed above, the major objectives to be achieved by this TA include:

1. Describing existing conditions in the western region as they relate to energy development, including geological, environmental, economic, social, and political factors.

2. Describing in standard format the various energy development systems as well as social controls which regulate such development. (See Section 3.2.)

3. Evaluating published models of national energy markets and using these to project high and low values of the demand for western energy in its various forms.

4. Assessing particular technological systems which appear likely to be deployed in various types of locations.

5. Determining the impact of hypothesized energy facilities on air and water quality and other relevant media.

6. Specifying relationships between changes in environmental quality and the affected flora, fauna, and human populations.

7. Assessing the adequacy of material, equipment, and human resources needed for western energy developments, especially water, transportation, equipment, manpower, and capital.

8. Determining the range of social impacts from developments at the local and regional levels in such areas as migration, housing construction, public finance, and life-style.

9. Identifying and assessing public options and implementation strategies for dealing with these impacts.

CHAPTER 2

CONCEPTUAL FRAMEWORK

2.1 INTRODUCTION

Although technology assessment (TA) is in large part a creative activity that cannot be approached as a search for formulas or models, a general conceptual framework has been developed for this TA. This framework is described in this chapter. The interdisciplinary team approach used to implement the framework is described in Chapter 5.[1] Past experience convinces us that a successful TA depends much more on the approach and the make-up of the interdisciplinary team than on the framework. The framework described in this chapter is a product of the approach as it has been employed in the past. As such, what is described here should be viewed as a stage of development rather than as a final product.

As a research activity undertaken to inform policymaking, TA has been motivated largely by the observation that the introduction,

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[1]The approach is also described in Kash, Don E., and Irvin L. White (1971) "Technology Assessment: Harnessing Genius." <u>Chemical and Engineering News</u> 49 (November 20): 36-41; and White, Irvin L. (1975) "Interdisciplinary," pp. 87-96 in Sherry Arnstein and Alexander N. Christakis (1975) <u>Perspectives on Technology Assessment</u>. Columbus, Ohio: Academy for Contemporary Problems.

extension, and/or modification of technologies produce a range of economic, social, environmental, institutional, and other first and higher order consequences.[1] In the past, many such consequences have not been anticipated. This is why the fundamental purposes of TA are to: (1) anticipate and systematically identify, define, and analyze these broadly ranging consequences; (2) identify, define, and analyze alternative policies for either mitigating undesirable consequences or enhancing beneficial consequences;[2] and (3) identify, define, and evaluate implementation strategies for feasible policy options. A simplified systems diagram of a general TA conceptual framework for achieving these purposes when assessing physical technologies is displayed in Figure 2-1. This diagram shows that the inputs and outputs of a technology interact with existing conditions to produce impacts, some of which are perceived to be problems or issues by one or more parties-at-interest or participants active in the policy system. Policymakers respond to some or all of the demands that problems or issues be resolved by searching out

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[1]For a recent description of TA, see Arnstein, Sherry R., and Alexander N. Christakis (1975) Perspectives on Technology Assessment, based on a workshop sponsored by the Academy for Contemporary Problems and the National Science Foundation. Columbus, Ohio: Academy for Contemporary Problems.

[2]Since what is considered desirable or undesirable varies among individuals and groups, desirability or undesirability has to be established on the basis of specific criteria. The criteria used in this TA will be made explicit when results are reported.

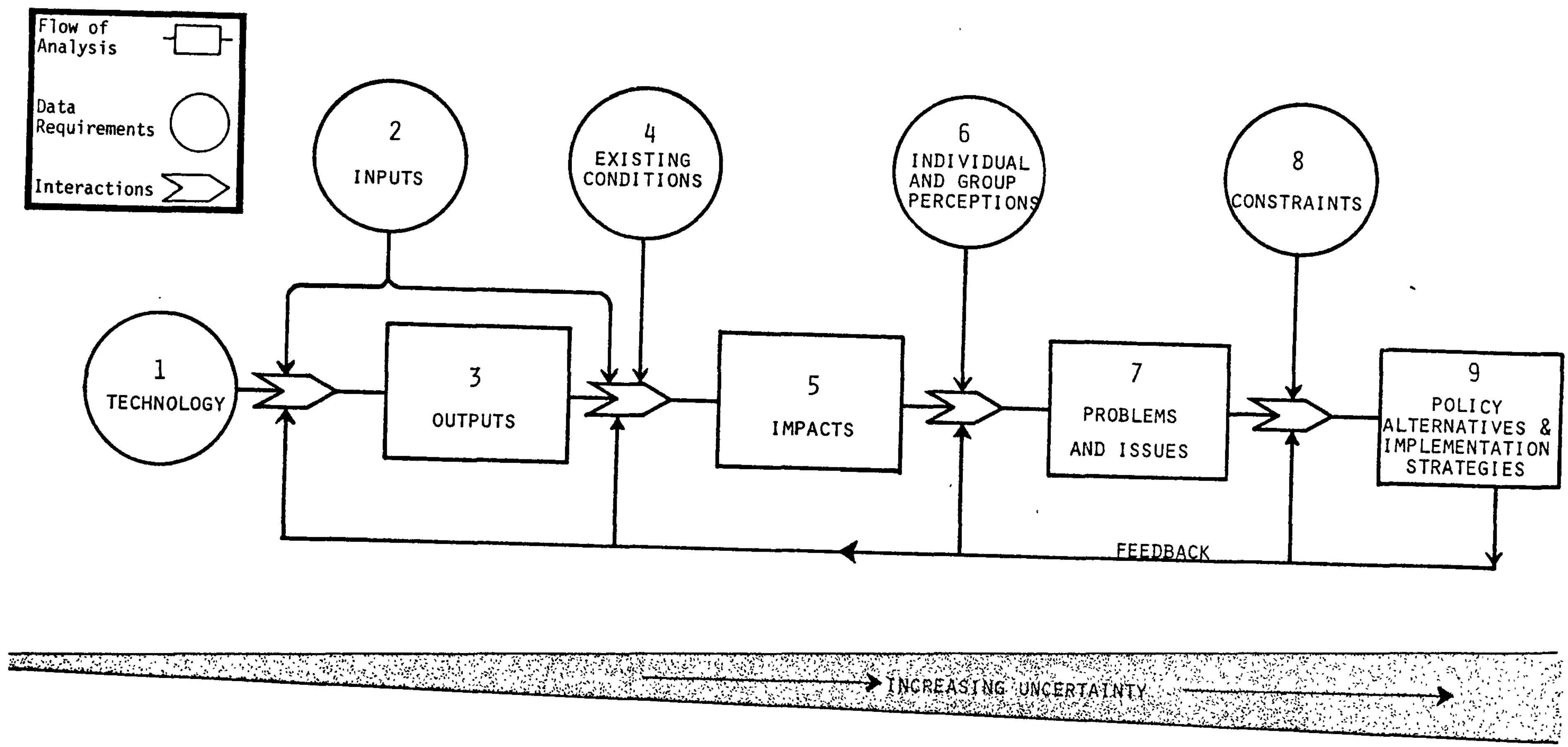

Figure 2-1: Conceptual Framework for Assessing Physical Technologies

feasible policy alternatives and implementation strategies.[1] All of this takes place under varying degrees of uncertainty. Generally, uncertainty is less with regard to physical technologies than with more subjective policy constraints. However, both input and output data for technologies, as well as data on existing conditions, are not always complete or reliable; nor are all impacts or interactions among impacts likely to be identified and their significance ascertained.

As implied in Figure 2-1, there are degrees of uncertainty associated with data and analytical tools--some data and tools are more reliable than others. Furthermore, uncertainty is compounded when the uncertainties associated with technologies, existing conditions, impacts, perceptions, constraints, and policies are combined. Consequently, the whole policy analysis task begins with an uncertain data and knowledge base. This difficulty does not lessen the need for TA; it does, however, highlight the uncertainties which underlie it as a research activity intended to inform policymakers. In short, TA is not a policymaker's panacea. A TA can help to organize and to some extent reduce uncertainty; it cannot eliminate it.

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[1]Criteria for establishing feasibility must also be specified, as they will be when policy analyses are reported. Chapter 5, Policy Analysis, describes the procedures that will be used to develop criteria of both desirability and feasibility.

The oversimplified nature of Figure 2-1 should also be stressed. For example, the system diagrammed is an open system. That is, the system is subject to the influence of external forces such as policy changes of the Organization of Petroleum Exporting Countries (OPEC).

Complex feedbacks are also oversimplified in Figure 2-1. For example, feedback from energy policy alternatives shows that: (1) policy alternatives and implementation strategies may modify individual and group perceptions, thereby resolving or modifying an issue; (2) policy alternatives can change the conditions which previously existed, especially as they interact with the outputs of technologies; and (3) policy alternatives and implementation strategies may call for a technological change or process alteration which eliminates, reduces, or otherwise alters the output which caused an impact to be perceived as a problem in the first place.

It should also be noted that the problems and issues to be assessed are identified in two ways. First, problems and issues are frequently identified by interested individuals, groups, and/or policymakers because the consequences of some action(s) have been or are anticipated to be significant enough to warrant public attention. This is certainly true in many instances with regard to western energy development where participants in the policy system have already perceived, among others, problems in air and water quality, water quantity, quality of life, and social infrastructure.

The second source of problems and issues is the unanticipated consequences identified by the TA. In fact, a major reason for conducting TA is to identify unanticipated consequences that will cause problems and issues to arise.[1] Problems and issues identified in both ways are introduced into the policy analysis process.

2.2 ASSESSMENT PHASES

The conceptual framework for TA being used in this study attempts to simplify the inevitable complexity confronting technology assessors and to make their tasks somewhat more manageable than they would otherwise be. In Figure 2-2, we show the three phases into which TA tasks are divided: the Descriptive, the Interactive, and the Integrative Phases. Although these three phases are essentially sequential at the outset of a TA, numerous feedbacks require frequent iterations as the TA progresses. (See Figures 2-1 and 2-2.)

2.2.1 The Descriptive Phase

Deploying a technology creates certain demands and produces a range of outputs or residuals in addition to the primary product. Demands include such general input requirements as

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[1]Problems may occur whenever there is doubt, uncertainty, and difficulty. A problem becomes an issue when a dispute develops. For example, revegetation of strip-mined lands was identified as a problem before it developed into a political issue.

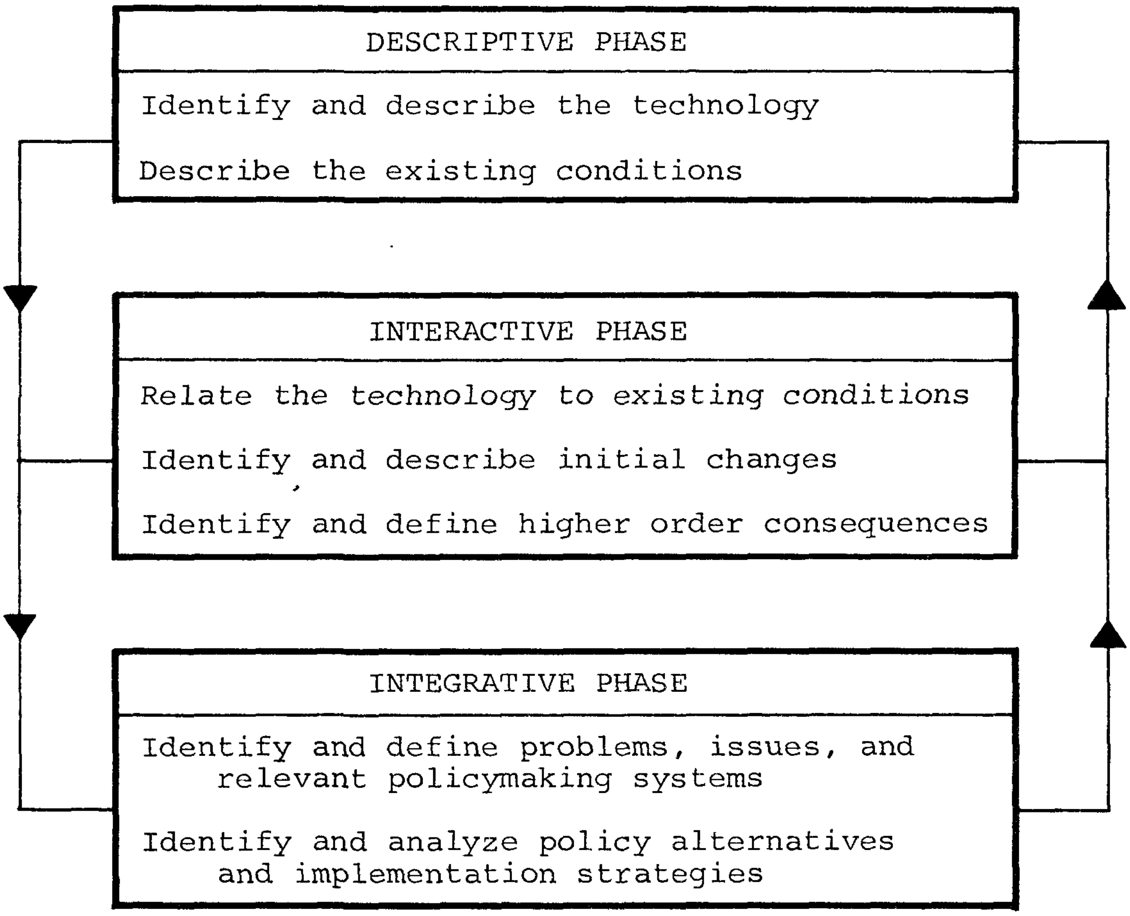

Figure 2-2: The Phases of a Technology Assessment

water, money, manpower, and materials. Outputs or residuals include, among others, pollutants such as air emissions and water effluents. Residuals also include such things as noise and aesthetics. It is the interactions of these inputs and outputs with existing environmental conditions which produce the impacts addressed by a TA. In the Descriptive Phase of a TA, the technology or resource development system[1] which is to be deployed and the place where it is to be deployed are described. Elements of the Descriptive Phase are indicated in Figure 2-3. The description of the technology includes the identification and quantification of inputs and outputs. A location has to be specified before existing conditions can be described. Scenarios can be used to do this.[2] By anticipating impacts and their potential range, it is possible to specify at least the principal baseline data likely to be required to analyze impacts at a specific location. Obviously, some impacts will extend beyond the immediate site at which the technology is deployed. For example, impacts produced by air pollutants are not likely to be as localized as are the impacts resulting from the generation of solid wastes. Consequently, when impacts are being anticipated as the basis for establishing initial baseline data categories,

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[1]For the explanation of what an energy resource development system is, see Chapter 3 and Appendix B.

[2]The scenarios to be analyzed in this study are described in Chapter 3.

STEP I	IDENTIFY AND DESCRIBE THE TECHNOLOGY For the single process (such as Lurgi gasification) or a combination of processes (such as coal mining, power generation, and high voltage transmission), specify: 1. Input requirements--water, capital, manpower, and materials, for example; 2. Outputs or residuals--high-Btu gas, SO_2, NO_x, particulates, sludge, liquid wastes, and noise, for example; 3. Social controls--such as permits and standards.

STEP II	DESCRIBE EXISTING CONDITIONS For the site or area within which the technology is to be deployed, describe existing conditions, including, among others: 1. Topography and geology 2. Climatology 3. Ecology 4. Social infrastructure 5. Sectors of economic activity 6. Land use patterns 7. Active parties-at-interest 8. Problems and issues 9. Policymaking systems

Figure 2-3: The Descriptive Phase

it is also essential that a first-cut analysis be undertaken to establish both the temporal and geographical range for these categories.

In summary, the product of the Descriptive Phase is the baseline data needed to determine impacts when a technology or technological system is interacted with existing conditions at a particular location. Given their tentative character, initial baseline data are likely to be revised and expanded throughout the TA. For this "Technology Assessment of Western Energy Resource Development," the products of the Descriptive Phase are descriptions of six energy resource development systems (ERDS), an overview description of the region, and descriptions of existing conditions at the locations specified in the scenarios. The use of these products will be described in Chapter 3, when the scenarios are identified and briefly described.

2.2.2 The Interactive Phase

Predicting the consequences of the deployment of a technological system is inherently a complex and difficult task. This complexity can be lessened somewhat by dividing impact analysis into two levels: the initial changes in existing conditions which occur when a technology is deployed; and the higher order consequences which flow from these changes. Initial changes in existing conditions might include, for example, changes in total population, land-use patterns, air and water quality, and an increased local demand for water resources. Consequences of these initial changes are then systematically traced to determine their higher order consequences. For example, the addition of specified quantities of air pollutants emitted from a coal gasification facility can change the existing air quality conditions in the surrounding area. The ambient concentrations of particular pollutants may be increased, for example. Health effects which might result from this initial change are illustrative of the higher order impacts that will be traced and analyzed. Another example is tracing the impact of overall population changes on the social infrastructure, on the capacity of the existing system to deliver social services such as education and health care, for example. (See Figure 2-4.)

2.2.3 The Integrative Phase

Policy alternatives are identified and assessed in the Integrative Phase. (See Figure 2-5.) This analysis includes procedures for identifying problems, issues, and relevant policymaking systems; determining a range of policy alternatives and implementation strategies, and assessing these as they are affected by a number of constraints.

Policymakers will often wish or be encouraged to attempt either to resolve or eliminate some of the problems and issues called to their attention. Not all of the policy options

STEP I	DETERMINE INITIAL CHANGES IN EXISTING CONDITIONS Determine the changes likely to occur when the technology is constructed, operated, and shutdown, for example, changes in: 1. Overall population 2. Concentrations of air pollutants 3. Land use 4. Water quality

STEP II	IDENTIFY AND ANALYZE HIGHER ORDER CONSEQUENCES Trace impacts to identify higher order consequences, for example, consequences for: 1. Human health 2. Social services 3. Sectors of economic activity 4. Quality of life 5. Power structure 6. Habitat attrition

Figure 2-4: The Interactive Phase

STEP I	IDENTIFY AND DEFINE PROBLEMS AND ISSUES Anticipated problems and issues identified as an existing condition; and Problems and issues which arise because of impacts identified by the assessment; and Policymaking systems for addressing these problems and issues.
STEP II	IDENTIFY AND DESCRIBE POLICY ALTERNATIVES AND IMPLEMENTATION STRATEGIES For the problems and issues that have been identified, identify and describe alternative courses of action by various levels of government. These could include: 1. Technological fixes--process changes and environmental control technologies, for example. 2. Regulatory action--stricter enforcement or revised standards, for example. 3. New legislation.
STEP III	IDENTIFY POSSIBLE CONSTRAINTS Policy alternatives and implementation strategies need to be filtered to determine whether there are constraints which will make them infeasible. Constraints may, among others, be: 1. Legal 4. Cultural 2. Political 5. Economic 3. Social 6. Technological

Figure 2-5: The Integrative Phase

available to them are equally desirable, feasible, or efficient. Some of the options may be technological fixes[1] involving, for example, process manipulations or the imposition of an environmental control technology; others may involve the imposition of regulatory controls or the tightening, enforcement, relaxation, or elimination of existing controls. Some options could be implemented by administrative order, while others might require legislative action. And some might be widely supported by the parties-at-interest who are actively involved, while others may be opposed so strongly as to be politically infeasible. Thus, the policy alternatives and implementation strategies that are proposed for modifying or eliminating undesirable higher order consequences have to be evaluated using more than the criterion of whether they could technically achieve the desired objective. A broad range of intervening variables such as social values and needs, the political strength of affected interest groups, economic costs, and other barriers to implementing the policy have to be taken into account in the assessment.

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[1]The term "technological fix" was coined by Alvin Weinberg to describe an approach to problem solving which emphasizes hardware development rather than modifying human behavior patterns. For example, a technological fix approach to auto safety is to make the vehicle so safe that it is difficult for humans to injure or kill themselves. An alternative approach is to attempt to modify the driving practices, for example, by convincing drivers not to drive when they have been drinking, not to drive at speeds unsafe for conditions, and so forth. Problem solving often combines the two approaches. But there has been a tendency in recent years to look for technological fixes to what are basically behavior problems.

2.3 SUMMARY

TA are undertaken to inform policymakers. The conceptual framework described in this chapter divides TA into three phases to produce policy-informing results. Although the three are closely interrelated, a distinctive analytical purpose is achieved within each. This purpose and the product of each phase have been described in general terms to explain and illustrate the rationale underlying this draft work plan for a "Technology Assessment of Western Energy Resource Development." In the chapters which follow, the adaptation of the general TA conceptual framework and how it is to be utilized in this TA will be made more explicit.

CHAPTER 3

THE DESCRIPTIVE PHASE

3.1 INTRODUCTION

In the Descriptive Phase of a technology assessment (TA), the technologies to be assessed and the place where they are to be located are identified and described. The products of the Descriptive Phase for this study include the following:

- A description of the energy resource development systems (ERDS). These include the technologies used to develop the resources, the inputs, outputs (including products and residuals) for these technologies, and the social controls (permit requirements and discharge regulations, for example) applied when these technologies are deployed.

- An overview of the western region which sets the context of the study and provides a basis for locating energy development facilities. This description includes an identification of some of the major issues which have arisen in connection with western energy development and which influenced the selection of developments to be assessed in this study.

- A description of the scenarios which configure various hypothetical patterns and levels of development whose impacts are to be determined in the Interactive Phase.

In this chapter each of these products will be described briefly. Because of their key role, the scenarios receive special emphasis.

3.2 ENERGY RESOURCE DEVELOPMENT SYSTEMS

Conceptually, an ERDS encompasses a resource, the technologies required to develop it, and the social controls that are imposed when these technologies are deployed. Descriptions of ERDS for each of the six resources--coal, oil shale, oil, natural gas, geothermal, and uranium--are being prepared and will be revised periodically to provide a data base for this TA.

The resource base description provides a national overview of each of the six resources and gives their distribution within the western states. It also divides the total resource endowment into categories on the basis of existing knowledge of the resource and the economic feasibility of recovery.[1]

The technologies description will include the major technological alternatives for exploration, extraction, conversion, and transportation of each of the six energy resources. Processes are described as are input materials and personnel requirements, outputs and residuals, energy requirements, and internalized costs. To the extent it is possible, these descriptions are quantified and detailed enough to illustrate differences among process alternatives.

The social controls descriptions generally identify the existing legal, administrative, and regulatory environment for

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[1]Theobald, P.K., S.P. Schweinfurth, and D.C. Duncan, eds. (1972) Energy Resources of the United States, USGS Circular 650. Washington: Government Printing Office, p. 3.

the six energy resources and the various technological activities related to their development, production, and transportation. The descriptions generally include existing requirements for permits, leasing regulations, standards, and other specifications affecting resource development.[1]

An outline of the oil shale ERDS is presented in Appendix B to show the organization and contents of an ERDS.

3.3 OVERVIEW OF THE WESTERN REGION

The purpose of the regional overview is to provide a general description of the context within which the development of western energy resources is taking place. The overview will include sections on topography, geology, weather patterns, water resources, ecology, socioeconomic conditions, transportation networks, intergovernmental structure (for example, interstate compacts and organizations), parties-at-interest, likely patterns of energy resource development, and development problems that have already been identified. The problems that have arisen either because of current or anticipated energy developments have played a major role in shaping the scenarios to be described in this chapter.

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[1]Informal practices and institutions such as interest group politics or related sanctions which have evolved to supplement the workings of the formalized elements will be described and analyzed in the site-specific scenario analysis.

The following are among the problems frequently mentioned when western energy development is discussed:

- Water quantity, both surface and ground, particularly in the arid and semiarid parts of the region and in the Colorado River Basin.[1]

- Water quality, as impacted directly by energy development and indirectly by increases in population.

- Air quality, particularly at locations and in areas where air quality is now quite high.[2]

- Distribution of costs and benefits with a concern on the part of some that the region is being asked to pay a disproportionate share of the associated costs of development.

- Intra- and intergovernmental cooperation and coordination.

- Capital availability, both for energy development and the front-end costs to local and state governments for social infrastructure developments such as schools, public health and safety, highways, and so forth.[3]

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[1]National Petroleum Council, Committee on U.S. Energy Outlook, Other Energy Resources Subcommittee (1973) U.S. Energy Outlook: Water Availability. Washington: NPC; and Radian Corporation (1975) A Western Regional Energy Development Study, Vol. III. Austin, Texas: Radian Corporation, Appendix B.

[2]Environmental Protection Agency and Federal Agency Administration (1975) An Analysis of the Impact on the Electric Utility Industry of Alternative Approaches to Significant Deterioration, Vol. I: Executive Summary. Washington: Government Printing Office.

[3]Bellas, Albert C. (1975) "Financing Coal Gasification Projects," in Clean Fuels from Coal Symposium II Papers, sponsored by Institute of Gas Technology. Illinois Institute of Technology, June 23-27, pp. 853-860; and Rocky Mountain Institute for Policy Research (1975) Financing Infrastructure in Energy Development Areas in the West. Snowbird, Utah: Rocky Mountain Institute for Policy Research.

- Reclamation of strip mined lands.[1]
- Alteration of life-styles, particularly for traditional cultures in sparsely populated areas and on Indian reservations.
- Displacement of present land users, for example, agricultural and recreational users.

These and other problems that are already being discussed in connection with western energy development will be identified in the regional overview. This context setting overview description will be used, as the first chapter, to introduce the TA in the first year report.

3.4 SCENARIOS

3.4.1 Scenario Introduction

Scenarios are postulated courses of action or events. In this TA, they postulate hypothetical patterns of energy development in the western U.S. from the present to 1980, 1990, and 2000; and they provide the basis for assessing the likely consequences of western energy development. Although the scenario locations are those where energy developments have in some cases been announced, the scenarios are hypothetical, and are not intended to be a substitute for an environmental impact statement (EIS).

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[1] National Academy of Sciences (1974) Rehabilitation Potential of Western Coal Lands, a report to the Energy Policy Project of the Ford Foundation. Cambridge, Mass.: Ballinger Publishing Company.

Their purpose is to: (1) provide a vehicle for the analysis of impacts and policies concerning a variety of western energy resource developments; and (2) provide a basis for generalizations about the consequences of various patterns, rates, and levels of development.

As configured here, scenarios are intended to:

1. establish research boundaries for the TA compatible with available research resources;
2. identify particular combinations of technologies and locations at which these technologies might be deployed;
3. identify baseline conditions to which changes due to energy resource development can be compared when impacts are assessed; and
4. set a context for the analysis of problems and issues which arise as a consequence of development.

These four purposes are closely related. The first purpose must be achieved since it is clearly impossible to assess every conceivable energy development which might occur within the western region. Consequently, it is important to choose very carefully from among possible energy developments. The second purpose, the identification of technologies and locations, is required so that inputs and outputs that will interact with existing conditions to provide impacts can be identified and described. The third purpose, identifying baseline conditions at particular locations, is necessary to permit comparisons and an evaluation of changes that will result from the energy developments proposed in the scenarios. The fourth purpose, providing a context for the identification of problems, is a necessary prerequisite to the policy analysis conducted in the Integrative Phase of the TA. The scenarios have been constructed to expose a range of problems. They provide a basis for examining a range of substantive public policy issues and the role of a wide range of parties-at-interest such as governments, Indians, energy companies, environmentalists, ranchers, and farmers.

To meet the requirement of addressing a broad range of impacts, problems, and issues during the first year of this TA, two types of scenarios will be utilized: site specific and aggregated. Site-specific scenarios allow the assessment of the development of one or more energy resources at a particular site using a particular combination of technologies over the time period covered by this study, 1975 to 2000. The six site-specific scenarios to be analyzed during the first year are intended to provide a basis for assessing impacts and identifying problems and issues that are likely to arise at local levels or that are associated with specific processes or technologies.

The aggregated scenarios are designed to provide a mechanism for examining problems and issues of regional significance. Three aggregated scenarios will be analyzed during the first year: the Upper Colorado River Basin (UCRB); the Upper Missouri River Basin (UMRB); and an eight state area made up of Montana, North Dakota, South Dakota, Wyoming, Utah, Colorado, Arizona, and New Mexico.

Since it is not possible to predict the course of future events with certainty, the scenarios are hypothetical. They represent plausible future developments and have been selected by the Science and Public Policy Program (S&PP)-Radian research team as vehicles for highlighting a broad range of policy issues likely to arise with the development of western energy resources. If the results of the first year TA demonstrate that additional scenarios are needed to enrich the assessment, particularly the range of impacts and problems to be analyzed, additional scenarios will be added for the second and third years.

While selecting a base case is always somewhat arbitrary, 1975 is the reference point that will be used in determining changes in existing conditions occurring at the sites and in the areas specified in the scenarios. In some cases, 1975 data may not be available, thereby necessitating extrapolation or the designation of another base year. The impact analyses will be structured so that impacts can be evaluated for alternative base cases, including the possibility of looking retrospectively at years prior to 1975.

In the following two sections, the six site-specific and three aggregated scenarios will be described. These include a discussion of how the scenarios were developed and a brief description of the scenarios themselves.

3.4.2 The Construction of Site-Specific Scenarios

As noted earlier, each site-specific scenario provides for the assessment of the development of one or more energy resources at a particular site using a particular combination of technologies. The assessment emphasizes two phases, construction and operation, but takes a third, termination or shutdown, into account.[1]

Three time periods are analyzed: present to 1980, 1990, and 2000. Levels of development are hypothetical. For the period from the present to 1980, these hypothetical developments are based on present developments and those that have been announced;[2] for the two later time periods, development levels are based on the quantities of energy expected to be produced in the western U.S. during those time frames, the resources located at the

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[1]Thirty years is the assumed operational lifetime of facilities. Construction is assumed to take from three to eight years; and facilities are not expected to produce at the levels specified at the outset. That is, start-time requirements are taken into account.

[2]Recent events such as the court's decision in Sierra Club vs. Morton, the fate of the synthetic fuels commercialization program, and President Ford's veto of the strip mining bill illustrate how uncertain forecasts of future developments can be. This only emphasizes that while these scenario developments may now seem plausible, they are hypothetical.

specific sites being assessed, and the technologies expected to be available.[1]

The procedural steps used to identify and construct the site-specific scenarios include the following:

1. A series of regional overlays were prepared which identified locations of:

    a. each of the six resources;

    b. existing, planned, and proposed energy developments;

    c. state, county, and reservation boundaries; and

    d. river basins and subbasins.

2. Specific sites and areas within these patterns of probable development were then examined to take into account such factors as topography, climatology, geology, hydrology, soils, plant and animal communities, and demography. Sites and areas were identified which appear to be either:

    a. generally representative of a class of sites and/or areas within the region; or

    b. unique sites with particular characteristics which would not be covered in the representative class, but might give rise to important problems or issues.

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[1] See Section 3.4.4 for a discussion of the energy development levels anticipated for the western region.

3. Socioeconomic and political criteria of representativeness or uniqueness were also taken into account, including seeking answers to such questions as:

    a. Will more than one state be impacted by development of this site or this area? (For example, will the development area cover parts of more than one state? Will the energy development take place in one state and most or many of the physical and socioeconomic impacts be borne by an adjacent state?)

    b. Who owns the surface and mineral rights?

    c. Will an Indian reservation either be the site of or be impacted by the development?

    d. Will a new community be required?

    e. What size communities will be impacted by the development?

    f. Are the required baseline data available?

On the basis of the steps above, six specific sites were selected for analysis. They are shown on the map, Figure 3-1. The temporal and spatial extent of impacts can vary. For example, the most severe impacts of primary air pollutants on ambient air quality is, in most cases, confined to a region within about 30 miles of a facility.[1] On the other hand, socioeconomic and ecological impacts can occur at much greater distances from the facility. Water quality and quantity impacts may require

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[1]Secondary air quality impacts such as photochemical oxidant and sulfate formation can occur at greater distances from a source. A portion of the analysis conducted in this TA will address the question of the spatial extent of the secondary air pollution problem.

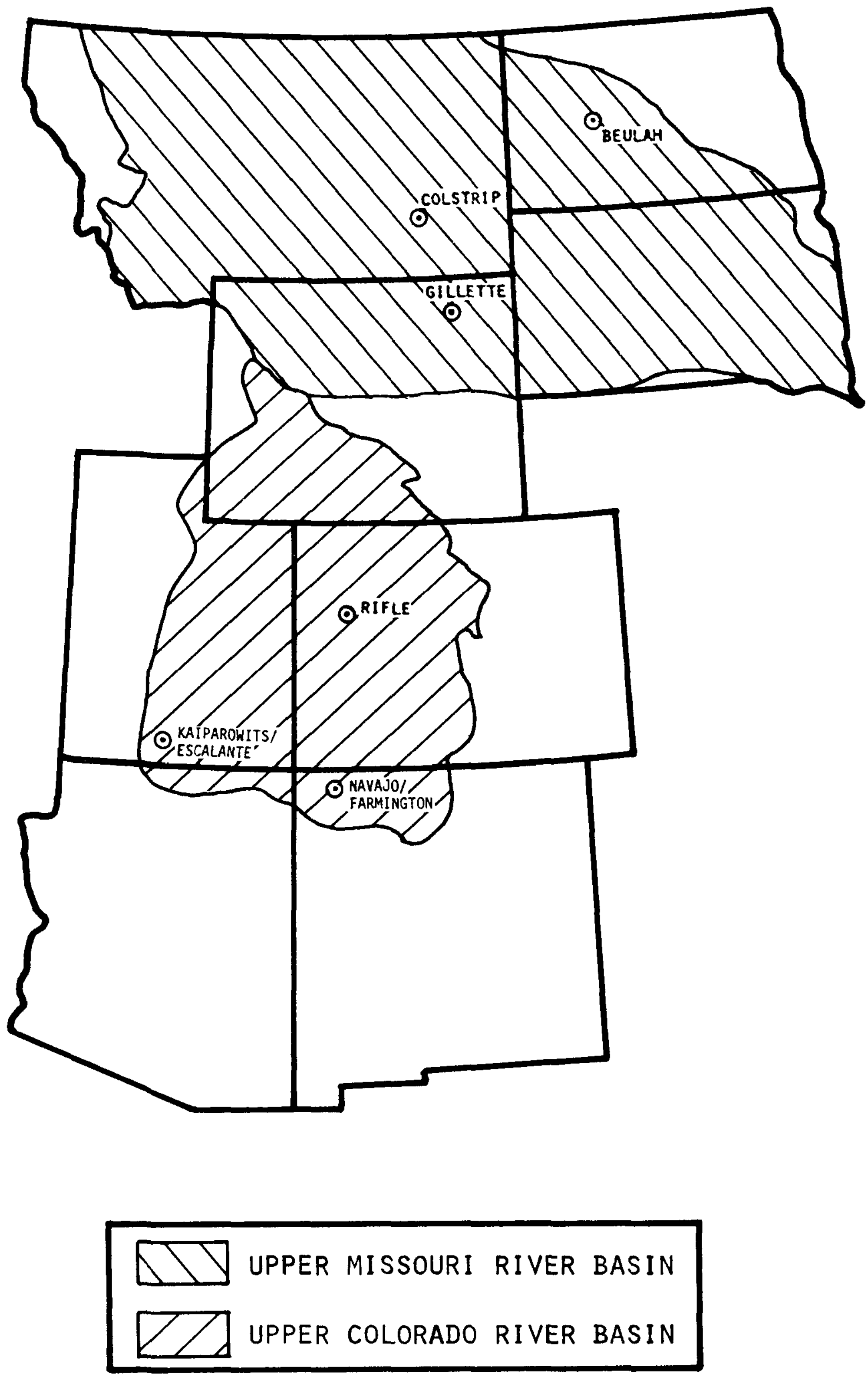

Figure 3-1: Site-Specific and Aggregated Scenarios

consideration of entire drainage basins. In constructing the site-specific scenarios, these differences were taken into account by determining the spatial extent of the impacts and establishing the geographic areas required for the various portions of the impact analysis in each scenario.

Technological alternatives were selected on the basis of their likelihood or availability for deployment on a commercial scale within the time frame of the study. Data accessibility and reliability were also considered. Production levels for individual mines, processing, conversion, and transportation facilities were based on what is typical or what has been announced.

Coal and oil shale conversion technologies chosen for the first year site-specific analyses include TOSCO[1] oil shale processing, Lurgi coal gasification, Synthane coal gasification, and Synthoil coal liquefaction. TOSCO has been under intensive development for some 20 years, and some impact data have been made publicly available. The Lurgi process is commercial, data are available, and announced plans call for it to be deployed in the western region. Moreover, some residuals data for Lurgi have been publicly reported.

Synthane is a second generation gasification technology. Since it is being developed by the Energy Research and Development

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[1]The Oil Shale Corporation.

Administration (ERDA), data are publicly available; and preliminary residuals data are currently available from small-scale facilities.

Synthoil is the liquefaction technology chosen to contrast with gasification. Although not quite as advanced in its development as some of the alternative liquefaction technologies, Synthoil is also being developed by ERDA, and the preliminary environmental data now available are in the public domain. In addition, Synthoil produces primarily liquid products rather than combinations of liquid and gas products. Data on most of the more advanced processes, such as COALCON, are proprietary. This was an important factor in the decision to select Synthoil as the liquefaction technology to be included in our scenarios.

One final point needs to be made concerning the scenarios to be analyzed. In postulating energy developments into the future, such state of society changes as possible shifts in societal values, changes in life-styles, and changes in the composition of the national work force (for example, the entry of more women) will be considered. To do this, we will use the procedural approach described in the discussion of policy analysis in Chapter 5. No attempt has been made to project state of society changes in the brief scenario descriptions presented in this chapter.

3.4.3 A Brief Description of the Site-Specific Scenarios

In this subsection, the site-specific scenarios to be assessed in the first year are described. Detailed data required for each of the facilities and areas included in the scenarios are being collected. As indicated in the conceptual framework discussion, a first-cut analysis is being used in an attempt to limit collection and codification to only those data actually required to assess impacts and analyze policy alternatives.

The six site-specific scenarios are:

A. Kaiparowits/Escalante: The Kaiparowits Plateau is located in Kane and Garfield counties in southern Utah. Large quantities of low-sulfur bituminous coal suitable for deep (underground) mining are located here. The plateau is very sparsely populated and is bounded by Glen Canyon National Recreational Area to the southeast, and Bryce Canyon National Park to the west, with a number of national forests and other parks within a 100 mile radius. Lake Powell, a reservoir in Glen Canyon on the Colorado River, may be considered as a water resource for energy facilities. Roads are very limited and there is no rail transportation. Land in the area is predominantly owned by the federal government (about 87 percent) with the remainder divided between state and private ownership. The nearest population center is Page, Arizona which has a population of between 7,000 and 8,000 people.[1]

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[1] A draft environmental impact statement has been issued for a coal-fired power plant at Kaiparowits. This statement will provide data and a basis for comparisons. See Department of the Interior, Bureau of Land Management (1975) Draft Environmental Impact Statement, Kaiparowits Project.

The issues which were considered in selecting the Kaiparowits/Escalante scenario include the following:

1. The use of underground mining on an arid plateau will raise reclamation issues, particularly with regard to subsidence and impact on groundwater aquifers.

2. The topography of the plateau and surrounding mountains makes prediction of air pollutant dispersion very uncertain, and consequently the adequacy of control techniques will be an issue.

3. The coal is a low-sulfur bituminous which should allow impacts from its use to be contrasted with those of poorer quality coals elsewhere in the West.

4. The use of the Colorado River as a water source and sink will affect and be affected by legal restrictions on water rights, and by water availability.

5. Socioeconomic impacts are potentially severe, due to the sparse population and lack of developed governmental services. This will create problems for local and state governments and the developers.

6. The proximity of the developments to national parks and other recreational areas will give rise to land use, air quality, and aesthetic issues. The significant deterioration of air quality is an issue at this site.

The energy developments postulated at Kaiparowits/Escalante for our scenario are shown in Table 3-1.

TABLE 3-1: POSTULATED ENERGY DEVELOPMENTS FOR KAIPAROWITS/ESCALANTE

Facility	Resource	Extraction (size)	Processing (size)	Transportation	Date of Operation
1	Coal	Underground (35,000 tons per day)	Mine-mouth Power Generation (3,000 Mw*)	Extra high voltage	1983
2	Coal	Underground (35,000 tons per day)	Mine-mouth Power Generation (3,000 Mw)	Extra high voltage	1987

*Megawatts

B. <u>Navajo (Farmington, New Mexico)</u>: The city of Farmington is about 50 miles southeast of Four Corners, and just east of the Navajo reservation. It has a population of about 22,000 people, which is about one-half the population of the county. Thirty-five percent of the county population is Indian, and 60 percent of the county land is Navajo Indian reservation. Utilities--the Four Corners power plants--and oil and gas developments are the major employers in the area. The land is flat and semi-arid, with only six to eight inches of rainfall annually.

The issues which were considered in selecting the Navajo scenario include the following:

1. The air in the area is naturally clear. However, air pollutant dispersion potential in the area is poor, making air quality and visibility issues for future energy developments.

2. Impacts to the Navajo reservation will be in many forms. Mineral and water rights are held by Indians and questions of water availability and fair value for resources will be issues. There will also be socioeconomic impacts on the Indian population which will generate issues.

3. Different transportation and processing technologies used for the postulated energy developments can be compared and may raise technological issues.

The energy developments postulated at the Navajo location for our scenario are indicated in Table 3-2.

TABLE 3-2: POSTULATED ENERGY DEVELOPMENTS FOR NAVAJO (FARMINGTON, NEW MEXICO)

Facility	Resource	Extraction (size)	Processing (size)*	Transportation	Date of Operation
1	Coal	Surface (20,000 tons per day)	Lurgi High-Btu Gasification (250 mmcf per day)	Gas Pipeline	1980
2	Coal	Surface (33,500 tons per day)	Mine-mouth Power Generation (3,000 Mw)	Extra high voltage	1985
3	Coal	Surface (18,000 tons per day)	Synthane High-Btu Gasification (250 mmcf per day)	Gas Pipeline	1990
4	Coal	Surface (33,300 tons per day)	Synthoil Synthetic Crude (100,000 bbl per day)	Oil Pipeline	2000

*Units are: mmcf = million cubic feet
Mw = megawatts
bbl = barrels

C. Rifle, Colorado: Rifle is on the eastern edge of the high grade, Piceance Creek oil shale resource basin and has a population of about 2,000 people. The terrain is rugged and mountainous. Extreme temperatures are experienced in the canyons and temperature inversions are common. Oil shale development has been promised to Rifle in various forms for the past 50 years, and residents today are skeptical about whether it will ever happen.

This issues which were considered in selecting the Rifle scenario include the following:

1. Oil shale is the primary resource in this area, and its development will raise issues of technological adequacy and reclamation, particularly reclamation effects on surface and groundwater quality.

2. Because of the likelihood of temperature inversions, air pollution will be an issue.

3. State regulations for Colorado studied in this scenario can be compared to those of other states in other scenarios.

The energy developments postulated at Rifle for our scenario are indicated in Table 3-3.

D. Gillette, Wyoming: Gillette is a town of about 10,000 inhabitants which has already experienced a boom because of energy developments. The population has doubled in the last 10 years, and further energy developments are anticipated which will contribute to continued growth.

The issues which were considered in selecting the Gillette scenario include the following:

1. The coal in the Powder River Basin is lower in quality than that at Farmington or Kaiparowits, but higher than lignite, and this scenario should provide a comparison of impacts from this coal with those of higher and lower quality.

TABLE 3-3: POSTULATED ENERGY DEVELOPMENTS FOR RIFLE, COLORADO

Facility	Resource	Extraction (size)*	Processing (size)**	Transportation	Date of Operation
1	Coal	Underground (9,400 tons per day)	Mine-mouth Electrical Generation (1,000 Mw)	Extra high voltage	1980
2	Oil Shale	Underground (70,000 tons per day)	Mine-mouth TOSCO II Retort (50,000 bbl per day)	Oil Pipeline	1985
3	Oil	Wells (tertiary recovery) (75,000 bbl per day)	None	Oil Pipeline	1985
4	Oil Shale	Underground (140,000 tons per day)	Mine-mouth TOSCO II Retort (100,000 bbl per day)	Oil Pipeline	1990

*bbl = barrels

**Mw = megawatts

2. A number of technologies can be contrasted at Gillette, and comparisons may expose problems or issues related to technological adequacy.

3. Socioeconomic impacts of rapid growth due to energy developments will be severe and will generate problems in adequacy of government services and other compensatory mechanisms.

4. Anticipated development is very large and will provide a basis for analysis of large-scale impacts.

The energy developments postulated at Gillette for our scenario are indicated in Table 3-4.

E. Colstrip, Montana: Colstrip is located in the Powder River Basin in southeastern Montana, about 30 miles south of the town of Forsyth. Colstrip is an unincorporated community of about 2,500 people, with most of its present population having arrived in the last three years to work on a large power plant project. Colstrip is just north of the Northern Cheyenne Indian reservation and northeast of the Crow Indian reservation. Roads in the area are limited, and mostly dirt or gravel, but a rail spur extends to Colstrip from Forsyth. In much of the area around Colstrip, surface ownership is private, devoted to ranching or agriculture, but mineral rights are federally owned.

The issues which were considered in selecting the Colstrip scenario include the following:

1. Resource ownership in the area is diverse, and the issue of surface versus mineral rights will be evident here.

2. Contrasting gasification technologies and their impacts can be compared.

3. Air pollutant dispersion can be contrasted with that from similar facilities in New Mexico to explore air quality issues.

TABLE 3-4: POSTULATED ENERGY DEVELOPMENTS FOR GILLETTE, WYOMING

Facility	Resource	Extraction (size)*	Processing (size)**	Transportation	Date of Operation
1	Coal	Surface Mine (68,500 tons per day)	None	Rail	1980
2	Natural Gas	Wells (250 mmcf per day)	Beneficiation	Gas Pipeline	1980
3	Coal	Surface Mine (68,500 tons per day)	None	Slurry Pipeline	1985
4	Coal	Surface Mine (25,800 tons per day)	Lurgi High-Btu Gasification (250 mmcf per day)	Gas Pipeline	1985
5	Coal	Surface Mine (35,100 tons per day)	Mine-mouth Electrical Generation (3,000 Mw)	Extra high voltage	1985
6	Uranium	Surface Mine (1,100 tons per day)	Milling (1,000 MT per year of Yellowcake)	Rail	1985
7	Coal	Surface Mine (22,200 tons per day)	Synthane High-Btu Gasification (250 mmcf per day)	Gas Pipeline	1995
8	Coal	Surface Mine (33,300 tons per day)	Synthoil Synthetic Crude (110,000 bbl per day)	Oil Pipeline	2000

*mmcf = million cubic feet

**Units are: Mw = megawatts
MT = metric ton
bbl = barrels

4. Montana state policies regarding energy resource extraction will be an issue--for example, severance tax and water allocation policies.

The energy developments postulated for the Colstrip scenario are indicated in Table 3-5.

F. Beulah, North Dakota: Beulah is a town of 1,300 people located in western North Dakota in the Fort Union lignite coal field. It is about 65 miles northwest of Bismarck, and much of the work force for energy developments at Beulah is likely to commute from the Bismarck area. Water resources for energy developments will probably come from the Lake Sakakawea reservoir, much of which is within the Fort Berthold Indian reservation.

The issues which were considered in selecting the Beulah scenario include the following:

1. Use of the low-sulfur, lower heating value lignite resource can be contrasted in impacts with the use of higher heating value coals elsewhere in the West.

2. The area is sparsely populated with a predominantly agricultural economy so that the new, large energy industry will produce socioeconomic disruptions and issues.

3. Bismarck may sustain substantial costs due to labor force population, but will not have the facility available for tax base, thus raising a cost/benefit distribution issue.

The energy developments postulated at Beulah for our scenario are indicated in Table 3-6.

A summary of the site-specific scenario technologies and their timing is shown in Table 3-7.

TABLE 3-5: POSTULATED ENERGY DEVELOPMENTS FOR COLSTRIP, MONTANA

Facility	Resource	Extraction (size)	Processing (size)*	Transportation	Date of Operation
1	Coal	Surface (45,600 tons per day)	Mine-mouth Electrical Generation (3,000 Mw)	Extra high voltage	1985
2	Coal	Surface (25,500 tons per day)	Lurgi High-Btu Gasification (250 mmcf per day)	Gas Pipeline	1990
3	Coal	Surface (23,000 tons per day)	Synthane High-Btu Gasification (250 mmcf per day)	Gas Pipeline	1995
4	Coal	Surface (33,000 tons per day)	Synthoil Synthetic Crude (100,000 bbl per day)	Oil Pipeline	2000

*Units are: Mw = megawatts
mmcf = million cubic feet
bbl = barrels

TABLE 3-6: POSTULATED ENERGY DEVELOPMENTS FOR BEULAH, NORTH DAKOTA

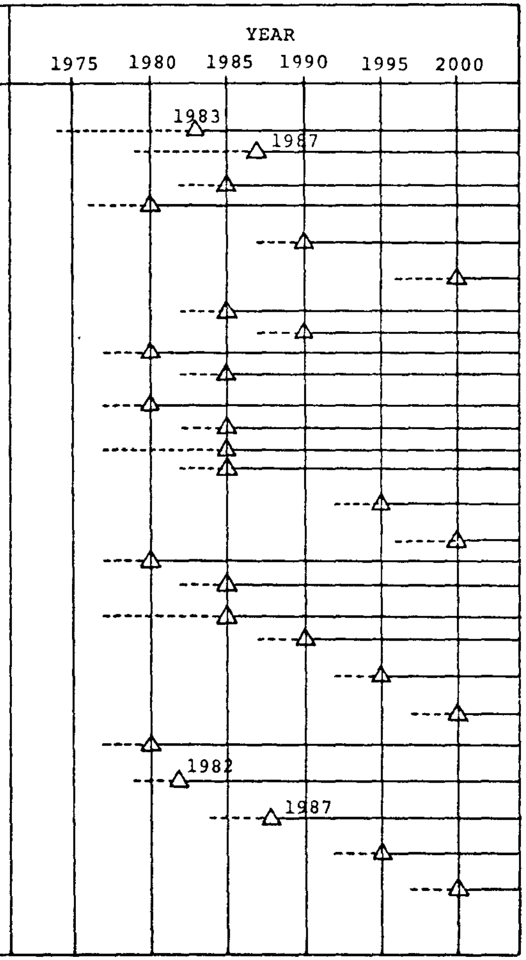
Facility	Resource	Extraction (size)	Processing (size)*	Transportation	Date of Operation
1	Coal	Surface (51,900 tons per day)	Mine-mouth Electrical Generation (3,000 Mw)	Extra high voltage	1980
2	Coal	Surface (30,400 tons per day)	Lurgi High-Btu Gasification (250 mmcf per day)	Gas Pipeline	1982
3	Coal	Surface (30,400 tons per day)	Lurgi High-Btu Gasification (250 mmcf per day)	Gas Pipeline	1987
4	Coal	Surface (26,200 tons per day)	Synthane High-Btu Gasification (250 mmcf per day)	Gas Pipeline	1995
5	Coal	Surface (26,200 tons per day)	Synthane High-Btu Gasification (250 mmcf per day)	Gas Pipeline	2000

*Units are: Mw = megawatts
mmcf = million cubic feet

TABLE 3-7: SITE-SPECIFIC SCENARIO TIME-PHASING

-------- Construction Phase (3 years nominal)
——— Operational Phase (30 years nominal)
△ On-Line Date

SITE	SCENARIO
Kaiparowits/ Escalante, UT	Coal-Deep Mine-Electrical Generation-Transmission (3,000 megawatts)
	Coal-Deep Mine-Electrical Generation-Transmission (3,000 megawatts)
Navajo/ Farmington, NM	Coal-Surface Mine-Electrical Generation-Transmission (3,000 megawatts)
	Coal-Surface Mine-Lurgi High-Btu Gasification-Pipeline (250 million standard cubic feet per day)
	Coal-Surface Mine-Synthane High-Btu Gasification-Pipeline (250 million standard cubic feet per day)
	Coal-Surface Mine-Synthoil Liquefaction-Pipeline (100,000 barrels per day)
Rifle, CO	Oil Shale-Deep Mine-TOSCO II-Upgrade-Pipeline (50,000 barrels per day)
	Oil Shale-Deep Mine-TOSCO II-Upgrade-Pipeline (100,000 barrels per day)
	Coal-Deep Mine-Electrical Generation-Transmission (1,000 megawatts)
	Oil-Wells – Pipeline (50,000 barrels per day)
Gillette, WY	Coal-Surface Mine-Rail Transport (25 million tons per year)
	Coal-Surface Mine-Slurry Pipeline (25 million tons per year)
	Coal-Surface Mine-Electrical Generation-Transmission (3,000 megawatts)
	Coal-Surface Mine-Lurgi High-Btu Gasification-Pipeline (250 million standard cubic feet per day)
	Coal-Surface Mine-Synthane High-Btu Gasification-Pipeline (250 million standard cubic feet per day)
	Coal-Surface Mine-Synthoil Liquefaction-Pipeline (100,000 barrels per day)
	Gas-Wells-Beneficiation-Pipeline (250 million standard cubic feet per day)
	Uranium-Surface Mine-Milling-Rail (1,000 metric tons yellowcake per year)
Colstrip, MT	Coal-Surface Mine-Electrical Generation-Transmission (3,000 megawatts)
	Coal-Surface Mine-Lurgi High-Btu Gasification-Pipeline (250 million standard cubic feet per day)
	Coal-Surface Mine-Synthane High-Btu Gasification-Pipeline (250 million standard cubic feet per day)
	Coal-Surface Mine-Synthoil Liquefaction-Pipeline (100,000 barrels per day)
Beulah, ND	Coal (Lignite)-Surface Mine-Electrical Generation-Transmission (3,000 megawatts)
	Coal (Lignite)-Surface Mine-Lurgi High-Btu Gasification-Pipeline (250 million standard cubic feet per day)
	Coal (Lignite)-Surface Mine-Lurgi High-Btu Gasification-Pipeline (250 million standard cubic feet per day)
	Coal (Lignite)-Surface Mine-Synthane High-Btu Gasification-Pipeline (250 million standard cubic feet per day)
	Coal (Lignite)-Surface Mine-Synthane High-Btu Gasification-Pipeline (250 million standard cubic feet per day)



3.4.4 Aggregate Scenario Development

As discussed in the scenario introduction, the aggregate scenarios will be used as a mechanism for examining issues and problems which are related to energy development in the West and which require a different basis for analysis than the site-specific scenarios. Two types of aggregate scenarios will be used: the regional scenario and the river basin scenarios.

Geographically, the regional scenario includes eight western states (Montana, North Dakota, South Dakota, Wyoming, Colorado, Utah, Mexico, Arizona) and provides a mechanism for investigating national energy demand projections and the resulting demands on the western energy resources. The river basin scenarios (Upper Colorado, Upper Missouri) will be used to further disaggregate energy demand projections and apply this demand to a smaller geographic unit. The analysis of the regional and river basin scenarios will include the impact categories considered in the TA. Within the river basin scenarios, the Powder River Hydrologic Basin and the Green River Geologic Basin will be highlighted. They are not scenarios because they will not be investigated by all disciplines but rather will be used only to address some specific impacts of intermediate geographical extent. The relations among the site-specific, river basin, and regional scenarios are indicated in Figure 3-2.

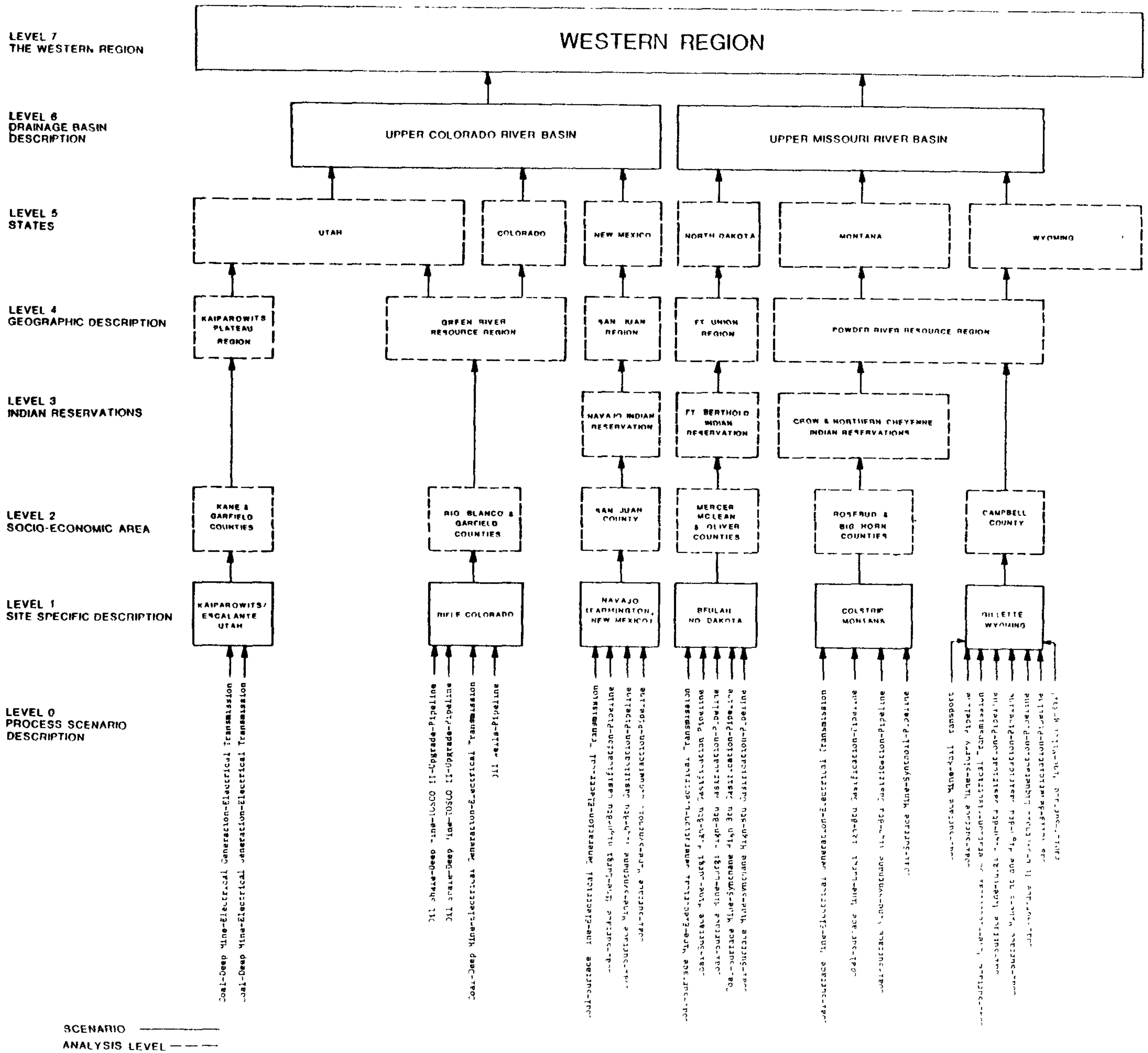


Figure 3-2: Aggregation of Scenarios and Levels of Analysis

The aggregate scenarios are developed by linking national demand projections and the resulting demands on the western energy resources. The relationship between national energy demand and western energy resources can be meaningfully developed only in the context of the entire U.S. energy system. More correctly, it should be analyzed in the context of the entire world's energy system insofar as it impacts the U.S.

Several energy supply models have been developed as tools for the analysis of the complex energy structure of the U.S. A preliminary survey indicated that five models appeared to be potentially useful in the development of the aggregate scenarios for this TA[1].

A more detailed analysis of the results of these five models was then performed. This analysis indicated that the Stanford Research Institute (SRI) model is the only one of the five which, in its present state of development, is capable of assisting in

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[1] These models were developed by Stanford Research Institute (Cazalet, Edward G. [1975] A Western Regional Energy Study: Economics, Discussion Draft. Menlo Park, Calif.: Stanford Research Institute), Federal Energy Administration (Federal Energy Administration [November 1974] Project Independence Report. Washington: Government Printing Office), Brookhaven National Laboratory (Brookhaven National Laboratory, Associated Universities, Inc., Energy/Environmental Data Group [1975] Energy Model Data Base User Manual, BNL 19200), The Bechtel Corporation (Carasso, M., J. M. Gallagher, K. J. Sharma, J. R. Gayle, and R. Barany [August 1975] The Energy Supply Planning Model. San Francisco: Bechtel Corporation), and Battelle Pacific Northwest Laboratories (Battelle Pacific Northwest Laboratories [July 1975] Regional Analysis of the U.S. Electric Power Industry. Seattle: Battelle Pacific Northwest Laboratories, vols. 1-6).

the development of the aggregate scenarios for the first year TA. The other models referred to above are either too limited in scope, not applicable to the time frame of interest, 1975 to 2000, or insufficiently disaggregated.

Bechtel's energy planning model gives construction schedules, time, capital, manpower and materials requirements for exogenous energy development scenarios. It is, therefore, not useful for regional scenario definition, but it should be useful for scenario analysis as a source of data for facility construction requirements and schedules. The Brookhaven model considers the U.S. as a whole. This complete lack of disaggregation renders the model unsuitable for aggregate scenario definition. The Federal Energy Administration's (FEA) PIES[1] model primarily focuses on the time frame, present to 1985. Since it only spans approximately half of the time frame of interest to this study, it is not currently useful for aggregate scenario development. Finally, the Battelle model addresses only the electric utility industry and is, therefore, not applicable to our regional scenario development.

SRI's model covers all major energy forms, conversion technologies, transportation modes, demand sectors, and U.S. geographical regions. It explicitly models supply elasticity, interfuel competition, and end-use demands and treats energy market dynamics such as investment, financing, technological change, demand growth, and resource depletion.

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[1]Project Independence Environmental Statement.

Demand for usable energy is exogenously specified. The SRI analysis cited considers three demand projections.[1] It considers a high- and a low-demand case corresponding to the Ford Foundation Energy Policy Study's historical growth and technical fix scenarios, respectively. The historical growth case examines the consequence of continuing an average growth rate of 3.5 percent per year. The technical fix case is an attempt to anticipate the results of a variety of voluntary and mandatory energy conservation measures. The third case is 30 percent of the way between the low-demand case and a high-demand case and is termed the nominal case.

Other important features of the SRI study are that:

1. It spans the time period 1975 to 2025 in a continuous manner.
2. The model considers the world energy situation, at least to a limited extent. (Import prices are exogenously specified.)

One of the important limitations of the SRI model is that it is not sufficiently disaggregated for the purposes of this TA and further disaggregation will have to be superimposed on the model results to develop the aggregate scenarios. This further disaggregation will be based on announced developments, and on an analysis of the geographical distribution of economically recoverable reserves of each resource.

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[1]Based on Ford Foundation (1974) A Time to Choose: America's Energy Future. Cambridge, Mass.: Ballinger Publishing Company.

Some important assumptions that may affect the credibility of the results obtained using the model are:

1. The model assumes that all western coal is low-sulfur coal and will not require scrubbers when it is burned to generate electricity. All eastern coal is assumed to be high-sulfur coal requiring scrubbers for its use.

2. An amount of water is assumed to be available if required.

3. The level of nuclear electric power generation appears to be unreasonably high--54 percent of the nation's electricity will be nuclear generated by the year 2000.

Nevertheless, the SRI model gives the best available projection of energy demands for the western states for the first year TA. Other aggregate scenarios which reflect the alteration of some of these assumptions can be considered in technology assessments for subsequent years.

3.4.5 Description of the Aggregated Scenarios

In this subsection, the three aggregated scenarios to be assessed in the first year are described. This description includes the geographical extent of the scenarios and the significant problems and issues considered in their selection.

Western States (Regional Scenario)

The regional scenario will include the eight western states of North Dakota, South Dakota, Montana, Wyoming, Utah, Colorado, New Mexico, and Arizona. All of the site-specific and river basin scenarios will be contained within this analysis. This eight-state region contains large quantities of the six energy resources being considered. Some of the principal issues that will be addressed in this scenario include:

1. The availability of existing transportation networks to meet the greatly increased demands for transportation of coal, gas, oil, and power;

2. The availability of the capital that will be required, both for energy and social infrastructure development;

3. The availability of labor sufficient both in number and skill to build the required facilities and to provide for the associated service needs caused by labor migrations; and

4. The availability of the required materials and supplies that will be needed for western energy resource development.

Upper Missouri River Basin (UMRB) Scenario

The UMRB aggregated region contains parts of Montana, Wyoming, North Dakota, and South Dakota. This area includes the site-specific scenarios at Colstrip, Montana; Gillette, Wyoming; and Beulah, North Dakota; as well as the aggregated Powder River Resource Region. The UMRB is an area where very extensive energy development is projected. Some issues that can be addressed at this larger scale that are not apparent at a smaller scale are:

1. The increased use of water will decrease the available supply used for instream needs such as navigation. A significant part of the nation's wheat harvest is transported by Missouri River barges and a decrease in the navigation season could be of national importance.

2. The widespread effects on wildlife habitat and recreational lands identified in the Powder River aggregate and the possible growth in agricultural land use could be addressed at this level.

3. The alternatives for water supply to the Powder River resource region include aqueducts from major downstream reservoirs which run through South Dakota. This aggregate would allow an investigation of the impact of that water supply alternative on ecological, agricultural, social, financial, and municipal structures.

As part of the UMRB scenario, the Powder River Basin will be studied in a limited analysis. This aggregate will include the Colstrip, Montana and Gillette, Wyoming site-specific scenarios as they are located within the larger boundaries of the resource region. The aggregate region includes parts of eastern Montana and northeastern Wyoming. The boundaries of the Powder River resource region are not specifically defined, but include the general area of the hydrologic basin of the Powder River and the associated portions of the Fort Union coal beds.

Some of the issues that can be addressed at this aggregate level that are not apparent at the site-specific level are:

1. The cumulative effect of multiple water withdrawals for industry, municipal, and agricultural users on streamflow and water quality.

2. The need for an extensive water transport system within the region to supply water users.

3. The identification of recreational needs that will have a widespread effect on the region and more specifically the Bighorn National Forest and Black Hills.

4. The socioeconomic effects caused by the cumulative impact of regional growth, for example, in Sheridan, Wyoming and on Indian tribes.

Upper Colorado River Basin (UCRB) Scenario

The UCRB aggregated region includes parts of Wyoming, Utah, Colorado, New Mexico, and Arizona and includes that part of the Colorado River Drainage Basin above Lees Ferry, Arizona. The site-specific scenarios at Rifle, Colorado; Kaiparowits/Escalante, Utah; and Farmington (Navajo), New Mexico, as well as the Green River resource region aggregate are within the area included in this analysis. The principal issues within this aggregate analysis include:

1. Reduced water availability in light of the reallocation of Upper Colorado River Compact waters as a result of recent statistical analyses that have revised the estimate of total available flow in the basin.

2. The problems associated with increased salinity caused by water withdrawals, return flows, and natural geologic conditions.

3. The development of water quality restrictions to the provisions of the Mexico Treaty.

4. The social, cultural, political, and economic impacts on Indians.

5. The impacts on air quality.

The Green River resource region will be analyzed on a restricted basis for water quality and ecological impacts. It includes the Rifle, Colorado site-specific scenario and both the Uinta and Piceance Creek Resource Basins within the Green River oil shale formation. This area contains both coal and oil shale resources and is a prime candidate for oil shale development.

The specific issues that are unique to this area include:

1. The increased salinity in Upper Colorado River water at downstream locations caused by the removal of higher quality water from the hydrologic system.

2. The cumulative effect of increased recreational use and widespread human activity on wildlife resources, including the largest resident deer herd in the surrounding three-state area.

3. The wilderness areas of the White River National Forest region will be receiving greatly increased recreational pressure. These extremely high quality wilderness areas are very fragile and could be jeopardized by heavy use.

CHAPTER 4

THE INTERACTIVE PHASE: IMPACT ANALYSIS

4.1 INTRODUCTION

A primary purpose of technology assessments (TA) is to prevent or at least minimize the surprises that could occur when a technology is introduced, extended, or modified. Therefore, an analysis of impacts is essential to identify unanticipated impacts. It is also important to establish the magnitude of impacts, both those that have been identified or anticipated prior to and determined by the TA. Both categories of impacts need to be evaluated and compared to provide a basis for understanding costs and benefits. In short, impact analyses are intended to produce results which lead to the identification of problems and which tell policymakers what costs and benefits are likely to occur when they decide to deploy a particular technology. As noted in the conceptual framework discussion (and elaborated in Chapter 5), technical impact analyses, by themselves, do not provide an adequate knowledge base for making public policy. In part, this is because of the inadequacy of the best of these analyses and the tools used to conduct them; but it is also the case because of what these analyses leave out, the kinds of interest and value conflicts which policymakers have to attempt to reconcile. In this chapter, the emphasis is on the technical analyses that will be conducted as an essential part of this TA. But these technical analyses are not an end in themselves; they are undertaken because the results they are expected to produce will help the Science and Public Policy (S&PP)-Radian team identify and analyze the policy problems and issues likely to arise in the development of western energy resources.

As indicated in the conceptual framework description, impact analyses are divided conceptually into two levels: the initial changes in existing conditions which occur when a technology is deployed; and the higher order consequences which result from these initial changes. Both levels of analysis are provided for in the procedures described in this chapter.

The methods and procedures for impact analysis are described in the sections which follow, beginning with impacts on physical receptors. Other sections focus on: resource availability; social, economic, and political impacts; ecological impacts; health; and aesthetics. Each of these sections generally includes: (1) an introduction of the significance of the analysis to policy development; (2) an identification of baseline data requirements; (3) a description of applicable models or analytical techniques; (4) a brief description of anticipated results; and (5) a description of data availability and the adequacy of existing research to support impact analyses required to support this TA. A final section of this chapter describes how these analyses will be brought together for use in policy analysis.

These categories appear to be sufficiently comprehensive to insure that a broad range of impacts will be identified and analyzed. However, the S&PP-Radian team is aware that some impacts might "fall through the cracks." One of the most important features of the interdisciplinary team approach and its associated external reviews is that it minimizes this possibility. This approach and the procedures for implementing it are described in Chapter 5.

4.2 PHYSICAL IMPACTS

The impact analysis procedures described in this section deal with changes in air and water quality, land form and quality, and noise levels. Changes in air and water quality due to both point and area sources of residuals from both energy facilities and their associated secondary developments are addressed. Changes in land forms deal primarily with solid waste management and reclamation. The section on noise focuses primarily on exposures from facilities and their associated activities, for example, from such activities as plant operation, blasting, and truck or rail transportation.

4.2.1 Air Quality

A. Introduction

Air quality impacts are to receive major attention. The results of these analyses are expected to provide data needed for other impact analyses, including ecosystem, socioeconomic, health effects, and aesthetic as well as policy analysis. Changes in air quality create problems and give rise to issues regarding the revision of emission and ambient air quality standards for criteria pollutants--and possible other pollutants in the future. A major issue, for example, concerns the development of regulations that would prevent significant air quality deterioration in such areas as national parks, forests, and recreation areas. The Environmental Protection Agency (EPA) must deal with this issue as a result of a June, 1973 Supreme Court decision, and Congress is considering legislation that deals directly with the significant deterioration issue. The House and the Senate have each developed plans that define significant deterioration. These differ from each other in several respects; and both differ from the current EPA plan.[1] Some version of these three different plans is expected to be enacted by Congress this term. If so, significant

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[1] Environmental Protection Agency and Federal Energy Administration (1975) An Analysis of the Impact on the Electric Industry of Alternative Approaches to Significant Deterioration. Washington: Federal Energy Administration.

deterioration regulations can be more accurately assessed. For this first year TA, then, the effects of all three plans must be considered separately and the results interpreted accordingly.

An example of the limitations that may be imposed on western energy development is contained in the joint analysis performed by EPA and the Federal Energy Administration (FEA)[1] on the impact of proposed significant deterioration plans on electric utilities. The results indicate that under the House significant deterioration approach, up to 91 percent of the land area in the West might not be available for the siting of a 1,000 megawatt (Mw) coal-fired power plant with emissions meeting EPA new source performance standards. The primary reason for this is that buffer zones must exist around Class I areas (areas of minimum allowable air quality degradation) so that pollutants are not transported by winds into the Class I areas. While it is possible to greatly reduce the size of the buffer zones for individual power plants by using better emission controls, it is apparent that extensive development will cause problems.

These and other air quality issues are intimately related to policies that affect facility siting, levels of development, and

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[1]Environmental Protection Agency and Federal Energy Administration (1975) An Analysis of the Impact on the Electric Industry of Alternative Approaches to Significant Deterioration. Washington: Federal Energy Administration.

requirements for specific environmental control items such as scrubbers or precipitators.

Significant variables to be addressed in air quality impact analysis are listed below:[1]

1. A variety of meteorological conditions and stresses

    a. Worst case conditions
    b. Short- and long-term average conditions
    c. Meteorological stresses

2. Ambient concentrations of criteria pollutants

    a. Sulfur oxides
    b. Nitrogen oxides
    c. Carbon monoxide
    d. Hydrocarbons
    e. Particulates

3. Fugitive emissions from facilities

4. Salt rainout from cooling towers

5. Sulfates and nitrates and oxidants*

6. Fine particulates, plume opacity, and long-range visibility*

7. Organic chemicals and trace element occurrence*

8. Potential for weather modification*

The assessment of several of these impacts will be primarily quantitative, including quantities of stack emissions, cooling tower drift, and fugitive emissions for each appropriate scenario. More descriptive analyses provide for assessment of changes in larger geographic areas, long-range visibility, the formation of secondary pollutants, and other factors.

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[1]Asterisk indicates that the analysis will be primarily qualitative.

B. Baseline Data

Data requirements for air quality impact analysis fall generally into two categories: meteorological information for the site or areas included in the scenario under consideration, including existing air quality data, and data on the technologies, including such factors as rates of emission and stack parameters. In many instances, these data are derived from sources through a number of calculations or analyses. Where appropriate, these are described below. Only general data requirements are described in this section, primarily as they apply to dispersion modeling of criteria pollutants. It should be recognized, however, that data requirements change or are modified for particular scenarios or specific modeling techniques, and that new data requirements will be identified as the TA progresses.

The initial survey of climatological data will include the processing of climatological tapes from the National Climatic Center, the investigation of topographical maps of the areas to be studied, and the collection of meteorological data describing the pollution potential of the western U.S. These include:

1. Ambient temperature and pressure
2. Mixing depths
3. Wind statistics
4. Inversion frequencies
5. Air stability classes--distribution and frequencies
6. Ventilation values
7. Precipitation frequencies

The tapes will provide frequency distributions of wind direction and wind speed as functions of the air stability classes, over a period of about five consecutive years. The most applicable source of meteorological data will be chosen for each scenario site to be studied. The topography of each site will be studied in detail so that the small- and medium-scale meteorological effects which prevail in the regions of interest may be ascertained. The topographical maps will be obtained from the U.S. Geological Survey (USGS) with a map scale of 1:24,000.

Using the inputs described above, conditions leading to the appropriate worst-case pollution potential on a 24-hour and other time frame basis can be hypothesized. Meteorological data will also provide a basis for both qualitatively and quantitatively describing the potential for dispersal of pollutants at each area of interest, including seasonal and annual statistics on mixing depths, transport wind speeds, inversion frequencies, Pasquill stability class distributions, precipitation frequencies, and other pertinent factors.

These individual medium-scale climatological assessments will be supported by a thorough discussion of the large-scale circulation patterns which affect the western U.S. This discussion will examine relationships between the upper-level circulation and boundary layer dispersion and seasonal and annual irregularities in the synoptic-scale flow. The effects of anabatic and katabatic circulations on dispersion in topographically favorable regions of the country will be addressed. These data will be used in a description of areas with exceptionally high or low dispersion potential throughout the western U.S.

Further research will be needed to specify the frequency of occurrence and severity of those meteorological events which may have a catastrophic effect on the regions of interest. Specifically, the phenomena which will be investigated will include major winds and storms which can cause flooding or damage. These data will facilitate engineering evaluations of the possible damage or destruction of facilities involved in this study.

The technological data requirements for dispersion modeling are stack parameters, pollutant emission rates, and other similar data appropriate for particular modes as listed below:

1. Stack height
2. Stack exit diameter
3. Stack location
4. Stack exit temperature
5. Stack exit velocity or flow rate
6. Pollutant emission rates

To be able to predict overall ambient air quality levels, it will be necessary to acquire data on the currently existing air quality in the locations of interest. These data are in the form of measurements of ambient concentrations of pollutants averaged over various lengths of time. Data sources include state agencies, regional offices of EPA, environmental statements, companies participating in the development of the region, and, when checked for appropriate quality control, the National Aerometric Data Base at Research Triangle Park.

C. Methods and Procedures

The analysis of air quality impacts will be conducted at two levels. First, ambient air concentrations of criteria pollutants for the scenarios will be computed, including sensitivity analyses relative to alternative control strategies; and, second, potential problems arising from a variety of other pollutants, including such parameters as sulfates, fine particulates, and trace elements and chemicals will be described. Included in the first level analysis described below are the predictions for each site-specific scenario of the ambient air concentrations of the pollutants sulfur dioxide (SO_2), nitrogen oxide (NO_x), carbon monoxide (CO), nonmethane hydrocarbons, particulates, cooling tower drift deposition, and, for the regional scenarios, predictions of total emissions of the above pollutants. Ambient air concentrations will be computed for a number of averaging times that may be useful for impact analysis--such as longer times for health effects doses. Peak concentration values will be computed in some cases for comparisons, since many of the standards apply to the peak values. Additional concentration values will be computed as required to assess levels over populated areas, typical levels, and for other purposes.

1. Dispersion Models

During the first year, atmospheric dispersion models will be used to compute the levels of airborne pollutants for the variety of terrain configurations, meteorological regimes, and source conditions encountered in the site-specific scenarios. Emission sources in this assessment effort fall into two basic categories: elevated point source releases; and low-level, area-wide releases of fugitive emissions. Appropriate dispersion model treatments have been selected for each of these emission source categories.

Examination of the terrain and meteorological regimes of the proposed site areas indicate that the following terrain-induced problems may be encountered in the modeling effort:

1. Influence of upward and downward sloping terrain on effluent transport
2. Deposition of airborne effluents on elevated terrain

3. Flow of airborne effluents over or around elongated ridges

4. Capture and channeling of low-level releases in valley drainage flow regimes

Two basic types of dispersion models were considered for use in the first year TA in response to these terrain factors: finite difference type models (sometimes called grid models) and Gaussian models[1] modified to incorporate terrain effects.

Finite difference models, such as the APDIC model developed at Lawrence Livermore Laboratories,[2] incorporate terrain effects by means of a terrain-compatible wind field (a complex, three-dimensional wind direction and speed definition). Definition of the wind flow field is accomplished by extrapolating measured wind data taken in the immediate vicinity of the site. This type of model requires numerous grid points which greatly increases the computer time required for each run. These models also need detailed wind field information.

The terrain-dependent Gaussian models are less accurate, but require much less computer time. Also, this type of model does not require the input of detailed terrain-compatible wind fields. Since the scope of this study is very broad (requiring the

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[1] Turner, D.B. (1970) Workbook of Atmospheric Dispersion Estimates, Public Health Service Publication No. 999-AP-26.

[2] Lange, Rolf (October 1973) ADPIC, A Three Dimensional Computer Code for the Study of Pollutant Dispersal and Deposition under Complex Conditions. Livermore, Calif.: University of California, Lawrence Livermore Laboratory.

dispersion modeling of 27 separate facilities) and the wind data required to generate detailed terrain compatible wind fields are not available, the terrain-dependent Gaussian type of model, a model commonly used in other studies in complex terrain, will be used.

Several models of this type have been examined to select the specific terrain treatment for use in the first year TA. The models considered are:

1. National Oceanic and Atmospheric Administration (NOAA) Model: During unstable and neutral conditions, the plume centerline is assumed to remain at a fixed height above the terrain. During stable conditions, the plume centerline is assumed to remain at a fixed height above the source. Application of this terrain treatment for periods of stable conditions results in the prediction of direct centerline impaction of the plume against terrain of height equal to, or greater than, that of the plume centerline.[1]

2. Model C7M3D (also called C9M3D): The terrain treatment employed by this model, developed by Edward W. Burt of the EPA, is identical to that of the NOAA Model for periods of unstable and neutral atmospheric dispersion conditions.[2] During stable conditions, the plume centerline is assumed to remain at a fixed height above the source, except that direct impaction of the plume centerline against elevated terrain is not allowed. Instead, as the plume encounters terrain of height equal to, or greater than, the plume centerline height, a separation of 10 meters between the plume centerline and the adjacent terrain is maintained. As the plume

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[1]Van der Hoven, Isaac, and others (March 1972) Southwest Energy Study: Appendix E. National Oceanic and Atmospheric Administration.

[2]Burt, Edward W. (1975) "Description of Terrain Model (C7M3D)." Private communication to Radian Corporation, Austin, Texas.

"rides up" the terrain, the calculated ground level concentration decreases from the value for the receptor located at the height of the plume centerline to a value of zero for the receptor located at a point 400 meters higher in elevation. As the plume "rides down" the terrain on the downwind side of the elevated obstruction, it treats receptors on the leeward slope in the same manner as those on the windward slope.

3. ERT Air Quality Model: This model accounts for elevated terrain by permitting the plume to be lifted one-half of the difference between the height of the receptor and the height of the stack base with the additional restriction that the plume always be at least half of its calculated equilibrium height above the ground.[1]

4. University of Colorado Air Pollution Generation and Dispersion Model: This model relies upon the input of representative local wind rose data to insure that the effects of terrain upon wind flow are properly treated. The terrain is assumed to shape the wind rose in mountainous areas. Furthermore, the model predicts direct impaction of the plume on elevated terrain if the terrain height equals or exceeds the height of the plume centerline.[2]

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[1]Environmental Research and Technology (November 19, 1974) Description of Gaussian Dispersion and Plume Rise Models, Appendix A. Concord, Mass.: Environmental Research and Technology.

[2]Howe, Charles W., Jan F. Kreider, and Bernard Udis (October 1972) An Economic Analysis of the Pollution Problems in the Colorado River Basin: The Upper Main Stem Sub-Basin. Boulder, Colo.: University of Colorado.

5. Box Model: The box model as described by Bruce Turner[1] treats the problem of the restriction of horizontal dispersion by the sides of a valley. When the horizontal dispersion coefficient becomes great enough, the concentrations can be assumed to be uniform across the width of the valley.

Based upon the specific sites and the similarity of terrain treatment in these techniques, the following methods were selected for use in the first-year: (1) releases from elevated sources will be advected at a constant level above the terrain for all stability conditions in areas of flat or gently sloping terrain; (2) in areas of abrupt discontinuities in terrain, the NOAA model terrain treatment will be used, with the exception that a ten meter minimum separation distance will be maintained between the plume centerline and the receptor. Concentrations resulting from the low-level, area-wide releases of fugitive emissions entrained in valley drainage flow regimes will be predicted using the box model.

These terrain treatments will be incorporated in short-term, medium-range, and long-term Gaussian dispersion models using the Briggs 1970 X_2 plume rise formula,[2] Pasquill-Gifford dispersion coefficients[3], and a special treatment for area sources. These

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[1]Turner, D.B. (1970) Workbook of Atmospheric Dispersion Estimates, Public Health Service Publication No. 999-AP-26.

[2]Briggs, G.A. (1970) "Some Recent Analyses of Plume Rise Observations." Paper presented at the International Air Pollution Conference of the International Air Pollution Prevention Associates.

[3]Turner, D.B. (1970) Workbook of Atmospheric Dispersion Estimates, Public Health Service Publication No. 999-AP-26.

three types of models and the area source treatment are as follows:

1. Short-term models (Predict concentrations for averaging times of three hours or less): Computations are made for any combination of wind speed and stability class desired, and the model may be exercised to identify "worst-case" wind direction and downwind distance to point of maximum impact.

2. Medium-range models (Predict concentrations for averaging times greater than three hours, but less than 24 to 48 hours): The averaging time period is divided into an integral number of shorter-term intervals with specific plant emissions and meteorological conditions which are assumed constant within a time interval, but which can change from interval to interval. For a given interval, the short-term model is used to compute the concentrations at particular receptors, and the final concentration for the desired averaging time is computed as a weighted average of the contributions from the individual time increments.

3. Long-term models (Predict concentrations for monthly, seasonal, or annual periods): This model uses statistical meteorological data (stability and wind rose data) collected at National Weather Service offices and computes concentrations for a grid of receptors based on the frequency of occurrence of different sets of meteorological conditions.

4. The fugitive emissions from low-level releases will be treated as area sources. These emissions from flanges, valves, or other leaks from processing facilities have been shown to be important.[1] For the short-term, medium-range, and long-term models, sources of fugitive emissions will be divided into a number of

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[1] Radian Corporation (February 15, 1974) Final Report: A Program to Investigate Various Factors in Refinery Siting. Austin, Texas: Radian Corporation.

rectangular areas for which uniform emissions throughout each area may be assumed. A two-dimensional integration will be performed over each rectangular area to determine the contribution of each area to each receptor.

2. Cooling Tower Drift Modeling

Although a number of plant cooling module configurations will be assessed in this TA, one important configuration for air quality analysis is the use of wet cooling towers. These towers result in a downwind plume of moist air with entrained water droplets which then "rain out" over the landscape. The model that will be used to predict cooling tower drift deposition is the Hosler Model.[1] This model is a ballistic type model that accounts for changes in fall velocities due to drop size and changes in drop size due to evaporation. Required as input to this model is the plume rise of the cooling tower plume. This will be calculated, based on Hanna's method[2] which considers the release of additional heat in the plume due to moisture condensation.

While there are more exact models available for drift deposition prediction, they were not selected because the impact of cooling tower drift is not expected to be significant, since

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[1]Hosler, C.L., J. Pena, and R. Pena (1974) "Determination of Salt Deposition Rates from Drift from Evaporative Cooling Towers." Journal of Engineering for Power/Transactions of ASME (July).

[2]Hanna, S.R. (December 1971) Cooling Tower Plume Rise and Condensation. Oak Ridge, Tenn.: National Oceanic and Atmospheric Administration, Air Resources, Atmospheric Turbulence and Diffusion Laboratory.

fresh water cooling towers will be used in all cases. The major impact of cooling tower drift deposition occurs when salt water cooling towers are used.

3. Persistent, Long-Range and Trace Materials Analysis

A number of residuals from energy facilities may be suspended for long time periods, travel long distances, change their chemical composition, or occur in particle size or amounts that are difficult to predict. These "small and large scale" effects are, in many instances, central problems for the establishment of standards, in part because the effects are little known or there are little data to develop definite criteria documents. For this reason, a good deal of EPA's research is currently focused to provide persons associated with the development of standards greater assurances about problems that now have high levels of uncertainty. To the extent possible, this TA will address these problems, particularly as they apply to our site-specific, aggregated scenarios. We underline, however, that this is not a study to develop new predictive models. Consequently, the approach to be used brings together the best available information to describe these issues of current interest. The following sections describe the importance and current level of understanding and our approach to these small and large scale effects, including descriptions of levels of atmospheric sulfates, nitrates, oxidants, and fine particulates, and the effects these may have on long-range visibility, plume opacity, and trace element and trace chemical concentrations, as well as weather modification.

a. Sulfate

Atmospheric sulfate has become the focus of increasing attention and concern, primarily because of reports of association between adverse effects and elevated atmospheric sulfate concentrations. Recent data on ambient sulfate levels collected by the National Air Surveillance Network has indicated elevated ambient sulfate levels over large areas of the eastern U.S. Other adverse effects of atmospheric sulfates on the environment have been associated with acid rain and the impact of particulate sulfates on weather, visibility, and climate.

It is generally assumed that a substantial portion of the elevated concentrations of sulfate aerosol found in the atmosphere derive from oxidation of SO_2. This oxidation produces sulfuric acid which condenses at very low concentrations to a liquid aerosol. Reaction of sulfuric acid with other atmospheric components may produce salts such as ammonium sulfate. The particle size of sulfuric acid or sulfate salt aerosols is in the submicron range, and particles may be transported for long distances as they do not settle out readily. Atmospheric sulfate is usually not produced at the pollution source, but in the atmosphere by chemical reaction. When coupled with the chemical stability and small particle size of the product, this makes modeling atmospheric sulfate concentrations a complex task.

Although empirical correlations have been derived between SO_2 concentrations and atmospheric sulfate levels, there is much scatter in the data and questions have been raised concerning the validity of the data base used. There is no general consensus as to the mechanism or mechanisms actually responsible for SO_2 oxidation in the atmosphere. Possible pathways for this reaction which have been reported to progress at rates high enough to account for the observed SO_2 oxidation in the atmosphere include:

1. Photo-oxidation in the presence of active hydrocarbons and ozone.
2. Gas phase oxidation in the dark in the presence of active hydrocarbons and ozone.
3. Gas phase reaction with ammonia in the presence of water vapor accompanied by oxidation.
4. Oxidation in aqueous solutions by dissolved molecular oxygen catalyzed by metal cations or ammonia.
5. Oxidation in aqueous solution by dissolved ozone.
6. Oxidation on the surface of solid particles (metal oxides or soot).

None of these proposed pathways has been shown to be the single dominant mechanism operative in the atmosphere. It is quite possible that different mechanisms dominate under different atmospheric conditions. The research team's approach will be to assess the general level of potential atmospheric sulfates to describe the extent to which sulfate addition from western energy development may contribute to the current problem.

b. Nitrates

The source and formation of nitrates in the atmosphere are not well understood. The precursor NO_x have both natural and anthropogenic sources; and they also probably have a wide variety of loss mechanisms besides nitrate formation. The impacts of nitrates also are poorly understood, but possibly include such important areas as visibility and health effects.

In addition to ongoing research programs on the occurrence, formation, and impacts of nitrates, much relevant information may be produced as a by-product of studies on sulfates. Active programs and results in both these areas will be monitored. As the state-of-the-art permits, these results will be used to assess the impact of nitrates derived directly or indirectly from new energy facilities in the West.

c. Oxidants

Oxidants include primary pollutants (emitted from specific sources) and secondary pollutants (formed in the atmosphere). Types of compounds include ozone, aldehydes, peroxides, peroxyacyl nitrates (PAN), NO_2, chlorine, bromine, and so forth. Present air quality laws are designed such that only ozone is measured for purposes of comparison to the standard; however, much uncertainty exists as to whether other oxidants may be more important with regard to impacts such as visbility changes, health effects, and property damage. The formation of the secondary pollutants such as ozone, peroxides, and aldehydes is not well enough understood to permit prediction of the time and levels of their occurrence. When combined with the uncertainty in the relative effect of the various species, this makes it difficult to predict site-specific impacts.

Considerable research is presently being conducted in the areas discussed above. The approach in this TA will be to identify these studies and to obtain the most recent results that are available. As the state-of-the-art permits, these results and existing information and theories will be used to define the impacts of new energy facilities with regard to oxidants.

d. Fine Particulates and Long-Range Visibility

Fine particulates are classified as particles that are less than one to three microns in diameter. These particles are of concern for health effects and aesthetic reasons since they are responsible to a large extent for visibility reductions that occur in polluted areas. Some fine particulates are ash particles produced as a direct result of fossil fuel combustion (primarily coal). Other fine particulates are produced by chemical reactions of pollutants in the atmosphere (sulfates and nitrates, for example). Fine particulates are not well understood (see discussions of sulfates and nitrates). The results of recent studies will be reviewed, and, to the extent possible, used to predict the impact of western energy development on fine particulate levels in the West.

Limitations on seeing distant objects (visibility) are caused by these fine particulates being suspended in the atmosphere and scattering light. At long distances, this scattered light reduces the contrast between objects to a level below the contrast threshold of the human eye, thus limiting the distance at which different objects may be distinguished. The theory of visibility is well-established. The reason that visibility impacts of pollutant sources cannot be predicted at this time is that the number and size distribution of the fine particulates cannot be predicted. Thus, treatment of visibility impacts in the first year will focus on data acquisition and the correlation of visibility impacts with ambient levels of criteria pollutants.

e. Plume Opacity

The opacity of a plume is caused by the particulates present in the plume in a manner similar to the way fine particulates limit visibility (that is, light scattering). Plume opacity is highly dependent upon the size distribution of the particles in the plume as well as their optical properties. Since these parameters cannot be predicted, the treatment of this impact will be limited to a discussion of the problem which will include, to the extent possible, estimates of the opacity range of the plumes.

f. Trace Elements

Trace elements are known to be associated with many energy raw materials. Much work has been done in the past few years to develop and implement rapid, economical, and accurate analytical methods for measuring these elements, particularly as they occur in coal. The elements of interest include those identified in Table 4-1.

A considerable body of data on trace element occurrence in coals is being developed. Some data are becoming available for oil shale; and the composition of some uranium ores is

TABLE 4-1: REPORTED RANGES IN TRACE ELEMENT ANALYSIS OF U.S. COALS

Trace Element	Concentration Range (ppm* of Coal)	
	Minimum	Maximum
Ag	0.1	5.0
As	0.3	93.0
B	5.0	280.0
Ba	10.0	1,390.0
Be	0.1	6.0
Br	4.0	52.0
Cd	0.03	65.0
Co	1.0	44.0
Cr	0.5	54.0
Cu	3.0	85.0
F	25.0	372.0
Ga	1.0	14.0
Ge	0.5	43.0
Hg	0.02	1.6
La	2.0	27.0
Mn	3.0	440.0
Mo	0.1	30.0
Ni	2.0	80.0
P	5.0	400.0
Pb	0.2	218.0
Sb	0.1	43.0
Sc	0.2	16.0
Se	0.1	8.0
Sn	1.0	425.0
Sr	4.0	960.0
V	11.0	86.0
Y	2.0	46.0
Yb	0.2	2.0
Zn	5.0	5,350.0
Zr	8.0	145.0

*ppm = parts per million

Source: Burklin, Clinton E. (August 1975) <u>Characterization of Waste Effluents from a Koppers-Totzek Gasification Plant</u>. Austin, Texas: Radian Corporation.

documented. Data on the occurrence of inorganics associated with oil and gas production are available for some known fields and can be expected to be supplemented for developing fields. Information on inorganics associated with geothermal resources is also becoming available.

The fate of trace elements in oxidizing atmospheres such as steam boilers has been determined in a number of cases. This information will be assembled, presented, and extended as additional information becomes available. For reducing atmospheres such as gasification or liquefaction facilities less data are available on the fate of trace elements and their presence as air emissions (and in water effluents, or as solid wastes). The limited information available from such sources as the Bureau of Mines and from licensors will be presented; and again, additional new data will be sought.

g. Trace Organics

Organic chemical emissions and effluents are expected to be an important issue in this TA. Only isolated data are available from small, old plants in the case of Lurgi gasification technology, and only from pilot or bench scale facilities in some other cases. Interpretation in terms of large-scale plants is tenuous. However, from experience in the coking industry, for example, and, from the limited data mentioned above, the presence of hazardous toxins, carcinogens, and so forth, can be expected in processing facilities. Classes of compounds such as those listed in Table 4-2, can be expected to be present.

It is not expected that quantification and detailed definition of the emissions will be known during the course of this project, since full-scale plant data will not exist within the project time frame. However, data relevant to the issue will be obtained and reported, both current data and those which can be expected to be generated by pilot facilities now being constructed.

h. Weather Modification

Weather modification resulting from energy development activities may include increased fogging and icing due to cooling tower plumes, decreased visibilities due to particulate matter emissions (described above), and changes in cloud formation and precipitation frequencies and amounts due to the release of submicron particles into the atmosphere.

The potential for local cloud formation and precipitation resulting from the increased releases of moisture and condensation nuclei should be examined. Because of the wide variability of local terrain and local meteorological regimes in the western U.S., empirical models predicting changes in cloud formation and

TABLE 4-2: SOME POTENTIALLY HAZARDOUS COMPONENTS FROM FUEL COAL PROCESSING FACILITIES

Hazardous Component	(TVL)* (ppm)**
Saturated Hydrocarbons[a,b]	100 to 500
Olefinic Hydrocarbons[b]	0
Monocyclic Aromatics[b]	10 to 100
Polycyclic Aromatics[c,d]	traces to 10
Heterocyclic Hydrocarbons[e,f]	0
Phenols[b]	5
Metals (as organometallics)	0

*TLV = threshold limit value for occupational exposure

**ppm = parts per million

Source: [a]Hydrocarbon Processing (1974) "Hydrocarbon Processing Refining Process Handbook." 53 (9).

[b]Melpolder, F.W., and others (1952) "Composition of Naptha from Fluid Catalytic Cracking." Industrial and Engineering Chemistry 44 (5): 1142.

[c]Hunt, R.H. and M.J. O'Neal, Jr. (1965) "The Composition of Petroleum," in John J. McKetta (ed.) Advances in Petroleum Chemistry and Refining, Vol. 10. New York: Wiley Interscience.

[d]Tye, Russell, and others (1966) "Carcinogens in a Cracked Petroleum Residuum." Archives of Environmental Health 13: 202.

[e]Wollaston, E.G., W.L. Forsythe, and I.A. Vosalos (1971) "Sulfur Distribution in FCU Products." Oil and Gas Journal 69 (August 2): 64-69.

[f]Lochte, Harry L., and E.R. Littman (1955) The Petroleum Acids and Bases. New York: Chemical Publishing.

precipitation should be developed for specific sites. Such models would correlate atmospheric particulate loading, absolute or relative humidity, and local and synoptic scale meteorological parameters with the occurrence of the formation of clouds and resultant precipitation.

D. Anticipated Results

The results of criteria pollutant air quality impact analysis will be ambient concentrations of SO_2, NO_x, CO, and total particulates and hydrocarbons computed for selected averaging times. These data will be in a form useful for describing pollutant doses so that potential ecological, social, economic, and health effects can be studied. Ambient pollutant levels will also be useful in issue identification for a number of potential policy problems such as siting individual or clusters of facilities, requirements for control devices or strategies for burning different qualities of coal, and the potential for exceeding federal and state ambient air quality standards.

The results of the cooling tower drift analysis will be expressed as land areas subject to saline mist so that such factors as potential for crop damage or rainout on various surfaces (such as glass cr metal) can be studied. The descriptive results of sulfates, nitrates, oxidants, and particulates will provide useful information for long-range or long-term problems, such as visibility reduction or acid rain that may affect pine tree growth. These long-range or long-term problems may be especially important in the formulation of new standards or other policies that may affect western energy development.

E. Data Adequacy

Although applicable data from climatological tapes are available for one of the scenario locations (Navajo/Farmington, New Mexico), in four instances major meteorological stations are more than 50 miles away. (Data from the National Climatic Center having the necessary observations do not include sites which are close to Gillette, Beulah, Colstrip, or Rifle.) The meteorological data source for Kaiparowits (Bryce Canyon) is less than 50 miles away, but may or may not be totally applicable to the Kaiparowits site because of terrain differences. Unless other applicable meteorological data sources (other than existing National Weather Service stations) for these five sites (all but Navajo/Farmington) can be located and used, considerable meteorological extrapolation will be required to transform the existing climatological data into a state more representative of the individual scenario locations.

In some cases, distributions of upper air observations may be needed to modify stability wind roses for those scenario locations which are in regions of particularly complex terrain (a situation which greatly affects the meteorology). Because of the meteorological extrapolations and modifications which must be attempted on the existing data, however, the uncertainty factor in the projections and modeling efforts that will utilize this data will increase.

Some meteorological data which provide estimates of the pollution potential of the various sectors of the western U.S. will be obtained from several sources, together with the climatological paper described earlier.[1]

One area of data adequacy that must be considered is that of the dispersion coefficients for rough terrain. Studies that have been made indicate that dispersion coefficients normally used in Gaussian dispersion models may not be applicable for rough terrain.[2] If this is the case, then further studies are required to determine what the proper dispersion coefficients for rough terrain are.

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[1] Holzworth, George C. (1972) Mixing Heights, Wind Speeds, and Potential for Urban Air Pollution Throughout the Contiguous United States. Research Triangle Park, N.C.: Environmental Protection Agency, National Environmental Research Center; and Hosler, Charles R. (1961) "Low-level Inversion Frequency in the Contiguous United States." Monthly Weather Review 89 (9): 319-339.

[2] See for example, Heimback, J.A., Jr., A.B. Super, and J.T. McPartland (1975) "Dispersion from an Elevated Source over Colstrip, Montana." Paper presented at 68th Annual Meeting of the Air Pollution Control Association, June 15-20.

F. Research Adequacy

The models and data needed for quantitative treatment of secondary pollutants, long-range visibility and weather modification in support of this TA are not available. While models do exist that predict secondary pollutant formation, these models have not been validated, or, at best, validated only for a specific region (for example, Los Angeles Basin oxidant models).

In the case of long-range visibility, the lack of data on particle size distribution is a particularly acute problem since even if concentrations of fine particulates, such as sulfates and nitrates, could be predicted, their size distribution would not be known. Another data inadequacy in this area is that of the complex indices of refraction for the various types of particulates (visibility is a strong function of this parameter).

Models that predict weather modifications that will occur due to large-scale energy development are limited to postulates of things that might happen or could happen. A good example of the uncertainty in this area is the two arguments of future temperature trends that will result from increased pollution:

1. The greenhouse effect--the CO_2 buildup will cause the atmosphere to act as a barrier to infrared radiation but as a window to visible radiation thus trapping heat and causing the earth's surface temperature to rise.
2. The return of the ice age--the buildup of particulates and photochemical oxidants in the atmosphere will reduce the amount of visible radiation that reaches the earth's surface so that temperatures will drop worldwide.

Problems may also be encountered in the prediction of the air impact of primary pollutants. The areas of concern are baseline ambient air quality data, meteorological data, and dispersion coefficients for use in rough terrain. Ideally, data on the existing ambient air concentrations of SO_2, NO_x, CO, and nonmethane hydrocarbons, and particulates for each of the site-specific scenario locations is required. However, due to the limited number of monitoring stations and the large extent of the western region, this goal will most likely not be met. Similar problems exist in the availability of meteorological data for each of the sites.

4.2.2 Water Quality[1]

A. Introduction

The purpose of water quality impact analysis is to provide information on changes in water quality for the ecological, socioeconomic, and health effects analyses as well as for the policy analysis of water quality issues. A number of issues have been anticipated, including the salt concentration in a number of critical rivers, such as the Colorado, where conflicts have developed over the quality of water for agricultural purposes and proposed changes to the Mexican Water Treaty of 1944. Solutions

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[1] Water quantity will be discussed in Section 4.3, Resource Availability.

to problems such as these can take the form of instream standards or permit requirements, limitations on water use, requirements for new technologies, or general limitations on the level of development of the western region.

The potential scope of water quality analysis can be very broad as new energy facilities, mining, and increased populations typically have a number of residuals that affect surface and groundwater quality, including, for example, changes in the types and concentrations of dissolved solids, addition of oxygen removing biological and chemical materials, and changes in physical properties such as turbidity and temperature. Although this TA will qualitatively identify the range of these changes in assessing the spectrum of water quality impacts, its focus will be primarily on anticipated impacts of major concern such as: changes in instream water quality as assessed by the increase in total dissolved solids (TDS) from both salt loading and salt concentrating effects; and biochemical oxygen demand (BOD) that are the result of municipal sewage discharges. TDS and BOD provide yardsticks for assessing the impact of water quality changes caused by two areas of major concern: effluents and water use from energy and municipal facilities. Other parameters useful in analyzing water quality are:

1. Ambient Surface Water Conditions

   a. flow
   b. depletions
   c. return flows
   d. salinity (background)
   e. instream requirements for biota and wild and scenic rivers

2. Groundwater

   a. ambient quality
   b. adaptability to various uses
   c. projected changes in quality
   d. pumping rates
   e. transmissivity
   f. existing regulations

Legislation identifying water quality as the source of significant problems and issues has been taken into account in structuring the water quality impact analyses to be described in this section. The pollution control strategy outlined in the Federal Water Pollution Control Act Amendments of 1972[1] is among the more important of these factors. This Act establishes national goals which include:

1. the elimination of the discharge of pollutants into navigable waters by 1985; and

2. wherever attainable, the achievement of water quality which provides for the protection and propagation of fish, shellfish, and wildlife and provides for recreation in and on the water (to be achieved by July 1, 1983).

These water quality goals have been interpreted in terms of technology-based objectives. The applicable technology objectives are as follows:

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[1] 86 Stat. 816. (Commonly referred to as P.L. 92-500)

Category	1977	1983	1985
Existing nonpublicly owned treatment works	Best practicable control technology currently available	Best available technology economically achievable	Where practicable, Zero Discharge of Pollutants (ZDP)
New nonpublicly owned treatment works	New source standards of performance, if promulgated, (generally aimed toward 1983 goals) which apply best available demonstrated control technology		Where practicable, ZDP
Existing publicly owned treatment works	Secondary treatment	Best practicable waste treatment technology	Allowance for recycle or reclaiming of water or ZDP
New publicly owned treatment works		Best practicable waste treatment technology	Allowance for recycle or reclaiming of water or ZDP

Although New Source Standards of Performance (NSSP)[1] have not been drafted for most of the processes considered in this TA, there are guidelines for steam electric power plants[2] and for both coal[3] and uranium[4] mining. Additionally, proposed Department of the Interior regulations presently exist for other coal mining

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[1]86 Stat. 816, Section 306(a).

[2]40 CFR 122; 40 CFR 423.

[3]Federal Register 40 (September 5, 1975): 41122.

[4]40 CFR 434.

operations which may have an effect on water quality.[1] If construction is begun on a privately-owned source for which no new source standards of performance have been promulgated, as is the case for most new energy process technologies, the effluent will still be subject to regulation by the EPA administrator[2] and applicable to state laws.[3] However, because of the considerable attention being given to energy resource development and new energy conversion technologies, NSSP may be in existence by the time these facilities are ready to go on-line. The effluent standards set by an NSSP can be made more stringent by state regulations.[4]

For purposes of a baseline analysis, it will be assumed that it is feasible to obtain ZDP for the energy developments included in our scenarios. However, sensitivity analyses will be performed addressing pertinent discharge alternatives such as: (1) TDS and waste-heat discharges; and (2) the discharge of those industrial waste streams which cause significant reduction in either treatment cost or waste volume. These analyses will identify the qualitative changes in water quality caused by these

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[1] 40 CFR 440.

[2] 86 Stat. 816, Section 402(a)(1).

[3] 86 Stat. 816, Section 510.

[4] 86 Stat. 816, Section 306(c).

waste streams and the impact of these changes on important species of biota.

There are several reasons for taking this approach. One is developing political pressures in the West. For example, in presenting proposed standards and an implementation program for salinity control, the Colorado River Basin Control Forum proposed that "as each state (in the Colorado River Basin) adopts the plan for implementation, the objective for industrial discharges shall be a no-salt return policy whenever possible".[1] Another is that the raw coals used in some of the scenarios contain a variety of trace substances including some heavy metals and produce possible carcinogenic organics. Some of these materials may well be added to the toxic materials list and it is possible that this action will cause additional pressure to be brought in support of the ZDP position. Because of the uncertainties involved in the ZDP issue, sensitivity analysis will be performed around this basic water quality goal to support the policy analyses.

Another assumption is that all industrial processes will also have to meet applicable state effluent guidelines and instream water quality standards. This means that different effluent concentration restrictions may be required for the same industry, depending upon the specific location of the discharge.

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[1]Colorado River Basin Salinity Control Forum (June 1975) Proposed Water Quality Standards for Salinity Including Numeric Criteria and Plan of Implementation for Salinity Control, Colorado River System.

This variation can occur as a result of different state criteria as well as unique water quality criteria for specific stream segments. To assess the impact of state water regulations on the release of effluents from the energy developments postulated in the scenarios, the ZDP sensitivity analysis will use state effluent regulations as one set of conditions.

The base case water quality analysis will address the problems of TDS pollution in the river basins under consideration because, although the postulated scenario developments may be restricted from returning salt to the rivers, the consumptive use of water may also have an effect on salt pollution.

The base case assumption related to the secondary effects associated with population growth is that municipal sewage treatment facilities will follow the guidelines presented in the Federal Water Pollution Control Act Amendments of 1972 for Best Practicable Waste Treatment Technology (1983 goal) with allowance for recycle or reclaiming of water or ZDP by 1985. Performance guidelines for the control of salinity from the return flows of irrigated agriculture will be incorporated in the analysis as they become available.

In addition to surface water problems, the disruption in groundwater flows and the alteration of groundwater quality due to strip mining operations and process use will be investigated in the existing literature. (For example, in some locations there may be indications that the water table around a mine could be lowered below the depths of domestic wells and cause springs and seeps to dry up.) Wherever sufficient data are available, the influence of surface pollution sources on groundwater quality will also be evaluated through examination of hydrogeological parameters relating those aqueous systems.

B. Baseline Data

Baseline data needs fall into two general categories: data needed to characterize and quantify the water consumed by and effluents from process units, municipalities, and other uses such as agriculture; and data needed to describe the existing conditions of the affected hydrological systems. In large part, the first data requirement will come from other sections of the TA. For example, data on the expected water consumption and effluents from the technological processes specified by the scenarios will come from the energy resource development systems (ERDS) described in Chapter 3. Data on population and land uses which will affect water uses will be produced by the social impact analyses described in this chapter.

C. Methods and Procedures

A number of modeling techniques are available, either as simple hand-calculated dilution and mass balance models or as more sophisticated computerized numerical models. The latter can either be in the form of: (1) site-specific stream-segment or basin models; (2) generalized models which are used for the prediction of conservative or nonconservative pollution transport and which must be calibrated and verified for a specific stream segment prior to use; or (3) site-specific stream-segment or basin models previously developed for a specific use. Because it is the nature of water models to be site (or basin) specific, generalized models will not be used.

Upper Colorado and Upper Missouri River Basins are described below:

1. Upper Colorado River Basin (UCRB)

   a. The Colorado River Salt Routing Model[1] is a planning tool developed by the Bureau of Reclamation as an interim measure to evaluate salinity impacts resulting from water resource developments and salinity control projects. It routes flow and salt through a river system and includes reservoir operations. The model is basically an accounting system with limited simulation capabilities. Flows and salinity are routed through the river system using a time frame of one month.

      Total dissolved solids are used as the quality parameter. Because mass balance concepts are

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[1]Huntley, Charles W. (1975) "Hydrologic Models Used in the Colorado River Basin". Presented at the U.S.-U.S.S.R. Group, Planning, Utilization and Management of Water Resources, Dec. 8-9. Unpublished paper, Denver, U.S. Bureau of Reclamation; and Ribbens, Richard W., and Robert F. Wilson (September 1973) Application of a River Network Model to Water Quality Investigations for the Colorado River. Denver, Colo.: Department of the Interior, Bureau of Reclamation, Engineering and Research Center.

employed, chemical precipitation, dissolution, and reactions of individual constituents are not modeled. These effects must be included by appropriate inputs. While flow is assumed to be independent of quality, quality does depend on flows.

Both bank storage and evaporation are included for reservoirs. Complete mixing of surface and groundwater in bank storage is assumed, resulting in a uniform reservoir water quality. Stratification, incomplete mixing, varying detention times, and variable withdrawal levels are ignored. For normal conditions, reservoirs use a lag of one month for computing the quality of releases.

Program inputs include the system configuration: reservoir characteristics, parameters, initial conditions, evaporation rates, and operating criteria; upstream and downstream boundary values; water use inputs; and run and output options. Output includes printed and cathode ray tube plots of results at various river locations and reservoirs.

This model is a general type model and there are no special subroutines for a particular river basin. It has been applied to the Colorado River Basin.

b. The Colorado River Simulation Model[1] is a more comprehensive model currently being developed for use on a wide range of problems in the planning, utilization, and management of Colorado River water resources. This model uses synthetic generation of river flow and salinity.

The model is being developed by the Engineering and Research Center, Bureau of Reclamation, Denver, Colorado, with assistance from the Bureau of Reclamation Regional Offices in Salt Lake City, Utah, and Boulder City, Nevada. It simulates streamflow and salinity in a river basin. The node concept is utilized with each node representing a specific reach of river. The node structure which the user

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[1]Huntley, Charles W. (1975) "Hydrologic Models Used in the Colorado River Basin." Presented at the U.S.-U.S.S.R. Group, Planning, Utilization and Management of Water Resources, Dec. 8-9. Unpublished paper, Denver, U.S. Bureau of Reclamation.

sets up for the model forms the pattern for all other inputs and model computational order. Computations are made on a monthly time basis.

This model provides the user the capability of varying demand and hydrologic inputs at points throughout the basin, thereby permitting an examination of the effects of these variations on water availability and salinity concentrations in the basin.

Four groups of inputs are required:

(1) Node structure
(2) Reservoir operational data
(3) Demand data
(4) Hydrology data

Several features have been incorporated into the general river basin model to reflect specific Colorado River operations. These include use of snowmelt-runoff forecasts for January through July reservoir operations, distribution of water between the Metropolitan Water District of California and the Central Arizona Project, water splitting between the Upper and Lower Basins, and storage requirements of the Upper Basin described in Section 602(s) of Public Law 90-537, and flood operations.

c. The Return Flow Prediction Model[1] is a comprehensive tool for: (1) predicting the quantity and quality of flow passing downward beyond the root zone and reaching the drainage system; and (2) predicting changes in soil chemistry resulting from irrigation. The model is divided into several subsections which address:

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[1]Huntley, Charles W. (1975) "Hydrologic Models Used in the Colorado River Basin". Presented at the U.S.-U.S.S.R. Group, Planning, Utilization and Management of Water Resources, Dec. 8-9. Unpublished paper, Denver, U.S. Bureau of Reclamation; and Shaffer, Marvin J., and Richard W. Ribbens (October 1974) Generalized Description of a Return Flow Quality Simulation Model. Denver: Department of the Interior, Bureau of Reclamation, Engineering and Research Center.

(1) Irrigation scheduling
(2) Unsaturated flow
(3) Drainout (amount of water leaving the aquifer per day)
(4) Saturated flow
(5) Chemistry interface
(6) Unsaturated chemistry
(7) Saturated chemistry
(8) Drain effluent prediction (quality of water leaving the aquifer)

Currently the following pollution parameters are identified in the model: nitrate, ammonium, calcium, sodium, magnesium, bicarbonate, chloride, carbonate, and sulfate. It is highly site-specific with regard to irrigated agriculture (which is not the main focus of this TA) and it is not expected that it will be used.

This model has been used in the Colorado River Basin by the Bureau of Reclamation.

d. The Hydro-Salinity Model of Utah State University[1] addresses flow and salinity within the UCRB but as it is an analog model, it will probably not be used in this study.

e. The University of Colorado Hydro-Salinity Model[2] is a digital computer adaptation and extension of the analog computer model developed by M. Leon Hyatt and others at Utah State University. The model consists of mathematical and logical representations of the various hydrological and routing functions which occur in all river basins. The model thus is not limited to any particular geographic area. The specific characteristics of each basin are incorporated into the model during the calibration process.

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[1] Hyatt, M. Leon and others (1970) <u>Computer Simulation of the Hydrologic-Salinity Flow System within the Upper Colorado River Basin</u>. Logan, Utah: Utah State University, Utah Water Research Laboratory.

[2] Howe, Charles W. (1975) <u>Primary and Secondary Impacts of Energy Development in the Gunnison River Area, the Hydro-Salinity Model Appendix</u>, Draft Report. Boulder, Colo.: University of Colorado.

The hydro-salinity model can be viewed as consisting of three components:

(1) an economic input/output interfacing package;
(2) a hydrologic model;
(3) a salt flow model overlying the hydrologic model.

Hydrologic flow data on some streams are available on a daily basis, but many other types of data necessary for calibrating and running the model are available only as monthly aggregates. This requires the model to use one month as its time unit.

The model includes an economic-to-hydrologic interfacing routine which takes total gross output data generated by a regional economic model and converts these into demands for water and other consequent impacts. The model also allows for the presence of both within-basin and end-of-basin reservoir storage. Since most within basin storage is used for irrigation, a feedback mechanism is included which translates shortages of irrigation water into increased reservoir releases.

2. Upper Missouri River Basin (UMRB)

   a. It appears that most water quality analyses in the UMRB have been done by hand calculations.

      As explained previously, calculations of this type are used to make simplified analyses of water quality changes. In general, hand calculations make general assumptions as to flow, river cross section, travel time (stream flow time from point to point), reaeration and deoxygenation coefficients, and temperature. Similar efforts may be used for analyses in the UMRB until models presently under development are completed, calibrated, and verified.

   b. Montana State University does have a program which models water flow and quality for the Yellowstone River. However, the one current model is still experimental.

The applicability of the Montana State model and the models discussed for the Colorado will be evaluated and one or more of the models may be exercised in cooperation with the developer. Wherever possible, these more specific basin models will be used to aid in establishing new values for pollution parameters that are of significance either during the construction or operation of the applicable scenarios.

New water quality computer models will not be developed during this investigation. Extensive use of computer modeling of water quality is not anticipated during the first year work effort. Instead, an investigation of water quality changes associated with salinity in the affected river basins will be made both locally and at a basin level analysis.

D. Anticipated Results

The water quality analysis will use the site-specific and aggregate scenario developments as tools to help identify and define issues related to water quality. Changes in the concentration or quantity of pollution, as defined by illustrative parameters, will be presented in graphs and tables that relate parameter changes to level of energy development, type of process, and location.

Additionally, the relationship between various legislated pollution control requirements will be defined and presented in an interaction chart that shows the relationship between the states through which the water flows and the changes in water-related regulations that are particular to those states. This product will provide the policy analysis with a tool that relates the changing instream quality and effluent-based regulations throughout the basin to significant jurisdictional boundaries and basin location.

A by-product of the water quality sensitivity analysis will be an interpretation of the necessary internal water use schemes that may be applied by process technologies to meet the required water quality standards. The outputs of the water quality analysis will be used in the ecological analysis as an aid in defining ecological issues. The identification of both water quality and ecological issues related to water quality will be the most significant result of the water quality analysis as these issues will provide the basis for subsequent policy analysis.

E. Data Adequacy

The primary data sources for this study are recent reports that have focused on the western water problems.[1] On-going research is focusing on some of the more obvious data analysis needs. Numerical models which accurately reflect the water flow and quality conditions of the basins to be most affected by energy development are, in some cases, being constructed. The UMRB data needs are more obvious than those for the UCRB.

The Colorado River Simulation Model described above will be documented by the summer of 1976 and, if the necessary data can be collected, will be available for use by January, 1977. This model will supersede the previous water flow and quality models in its total capability to manage water in the UCRB but will not provide a capability for independent subbasins.

The Montana Department of Natural Resources is currently developing a model for flow in the Yellowstone River Basin as a major part of a program being funded by the Old West Regional

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[1] Ficke, John F., John B. Weeks, and Frank A. Welder (1974) Hydrologic Data from the Piceance Basin, Colorado, Colorado Water Resources Basic-Data Release No. 31. Denver, Colo.: Colorado Department of Natural Resources and U.S. Geological Survey; and Missouri Basin Inter-Agency Committee (1971) The Missouri River Basin Comprehensive Framework Study, 7 vols.; and Northern Great Plains Resources Program, Water Work Group, Water Quality Subgroup (August 1974) Discussion Draft. Denver: Northern Great Plains Resources Program; and Water Resources Council, Upper Colorado Region State-Federal Inter-Agency Group (1971) Upper Colorado Region Comprehensive Framework Study and Appendices.

Commission. This program could be modified to address water quality problems if more funding was available. Generally speaking, raw data are available but the basin-specific analysis capabilities need to be improved.

Montana State University has a current contract with EPA to develop a new flow and water quality model of the Yellowstone Basin. This model is expected to be verified by January 1977.

Data on groundwater are available from several sources. Although existing data are generally diffuse and in need of interpretation, twenty-four research projects related to groundwater availability and quality currently underway in the UMRB have been identified.[1] Similar projects are being identified in the UCRB.

F. Research Adequacy

Water has been identified as one of the more significant issues concerning energy resource development in the West. Although water quantity has received most of the attention, water quality problems have also been studied. The continued emphasis on water-related problems in the western states should insure that increased research is conducted in this area. Since 1970,

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[1]Old West Regional Commission and Department of Agriculture, Forest Service (1975) Energy Research Information Service (ERIS) Quarterly Report 1 (November).

a number of major inputs have been made into the understanding of western water problems. Several groups are presently funding research in water quality related to energy development. For example, EPA is supporting germane research in:

- The Environmental Assessment of High-Btu Gasification
- Proposal for an Environmental Assessment of Effluents from Coal Liquefaction
- Environmental Assessment of Coal Cleaning Process
- Study of Disposal of By-Products from Nonregenerable Flue Gas Desulfurization Systems
- Survey of Environmental Regulations and the Assessment of Pollution Potential and Control Technology Applications for Geothermal Resource Development
- Water Conservation and Pollution Control Alternatives in Coal Gasification and Liquefaction Processes
- Optimizing Wet/Dry Cooling Towers for Water Conservation and Plume Abatement
- Manual of Practice to Control Sediment and Erosion During Mining
- Pollution Control Guidelines for Coal Refuse Piles and Slurry Ponds
- An Evaluation of the Environmental Impact of the Existing Surface Mining Methods for Western Coal Mines

All of the above projects would have some data input to water quality analyses. Forty-two research projects are currently identified for the UMRB. Seventeen of these are related to surface water quality.[1] These projects have been identified

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[1]Old West Regional Commission and Department of Agriculture, Forest Service (1975) Energy Research Information Service (ERIS) Quarterly Report 1 (November).

through the efforts of the Old West Regional Commission to catalogue all research related to energy development in the Old West area (Montana, Wyoming, North Dakota, South Dakota, Nebraska). Similar efforts are being identified for the UCRB. For example, the Western States Water Council is currently involved in the identification of research within the western states to include the Colorado River Basin.

The identification of current research will be used as a tool in the analysis of research needs in the water area. The research adequacy report that will be generated as part of this TA will include these findings.

4.2.3 Solid Waste

A. Introduction

The impacts of solid waste disposal raise significant issues for western energy development, particularly in oil shale and coal development. For example, issues in coal development arise in connection with separation and reuse of topsoil, strip mining, uncertainty over the fate of heavy metals, locating disposal sites for sludges, exporting part of the solid waste, and permeability changes in reclaimed surfaces and underground mines that affect groundwater aquifers. In addition, secondary municipal developments result in increases in solid waste disposal.

However, these are not of equal magnitude with those of some of the mining and processing facilities.

Three categories of impacts will be addressed in this analysis: (1) potential disposal sites for the spoils waste; (2) a description of problem compounds present in the solids; and (3) the movement of chemicals through soil media. The last two categories include, where possible, the heavy metal content of coal ash and any radioactive isotopes in coal ash, coal gasification wastes, or uranium milling tailings. The higher order impacts derived from these problems are discussed in the analysis of ecological, social, economic, and political impacts. Reclamation problems are discussed in the Ecological Impacts section (Section 4.5).

B. Baseline Data

Three kinds of baseline data are essential for assessing solid waste impacts: (1) descriptions of technological activities and associated solid waste residuals; (2) data on existing conditions such as soil type, topography; and (3) anticipated municipal developments associated with energy facilities. Although the new technology processes that will be used in some of the developments postulated in the scenarios have not been completely defined in terms of their effluents and waste products, the solid waste effects of exploration, coal strip mining, and some of the other process steps are known and are included in the residuals data section of the descriptions of each of the ERDS. Residuals data include quantities of overburden, ash, recovered elements (for example, sulfur), stack gas cleaner sludge, spent shale, tailings from uranium milling, and suspended solids removed in water treatment. Existing topographic data are available from USGS maps; much of the soils data and other environmental parameters are available from the Bureau of Land Management and state agencies. Data on municipal developments will be drawn from population projections developed when social, economic, and political impacts are assessed and from extrapolations of waste discharge patterns of communities with similar characteristics located in the western region.

C. Methods and Procedures

By systematically comparing disposal requirements with locations and conditions available at the sites, potential sites and site hazards will be identified. These conditions will be checked against a number of criteria, including soil stability and slope, and the availability of locations meeting such economic criteria as reasonable distance and configuration for dumping or surface restoration. Initial criteria to be employed for aesthetic and health reasons, as well as for revegetation potential will be introduced in this section of the impact analysis. However, more detailed analysis of ecological, health, and aesthetic impacts will be assessed in the sections of impact analysis devoted to those areas (Sections 4.4, 4.6, and 4.8).

The composition of potential waste or spoils will be reviewed to the extent that site-specific data are available or to the extent that historical analogies from similar sites can be made. This will permit a listing of potential problem compounds.

Movement of materials such as existing salts or compounds introduced into disposal sites will be made by estimating potential for percolation through soils of varying permeability. In cases where only limited data are available, data may be presented as a rank ordering of comparative movement through soils, rather than as estimates of actual soil transport rates.

D. Anticipated Results

Most of our results will be descriptions of the relative adequacy or inadequacy of disposal sites, lists and rankings of potential problem compounds in the disposed materials, and descriptions of the movement potential of materials through the soil media. Results of revegetation problems, health risk and other higher order consequences will be described in other relevant sections.

A qualitative assessment, based on climatological conditions at the site and on reclamation studies of similar wastes in other regions, will be prepared. Similarly, evaluation of the higher order leaching impacts will be based on experiences in other areas.

E. Data Adequacy

Data on the quantity of solid wastes is more reliable than data on the composition of residuals. In addition to information existing in the literature, data on solid waste composition will be upgraded through direct contact with developers and agencies investigating solid waste disposal.

F. Research Adequacy

A number of more specific problems relating to solid waste disposal have been the focus of recent research. In the case of oil shale development, for example, the Environmental Resources Center at Colorado State University has completed initial stages of research on the surface rehabilitation of land disturbances resulting from oil shale development.[1] In other states, research has focused on stabilization of disposal sites, although there is considerable uncertainty still associated with the results. Prediction of leaching of materials through soils requires site-specific testing and evaluation. Until this information is

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[1] Cook, C. Wayne (1974) Surface Rehabilitation of Land Disturbances Resulting from Oil Shale Development, Final Report, Phase 1. Fort Collins, Colo.: Colorado State University, Environmental Resources Center.

available for all the sites selected in this analysis, quantitative results will be inadequately supported.

4.2.4 Noise

A. Introduction

Two types of noise will be evaluated: environmental noise and occupational noise. Environmental noise is a combination of noise exposure to all sources of noise in nonjob-related activities. Occupational noise is that to which an employee is exposed during his working day as a direct result of his work requirements.

These impacts have been addressed by the Occupational Safety and Health Act of 1969 and the Federal Noise Control Act of 1972. The latter established a national policy "... to promote an environment for all Americans free from noise that jeopardizes their health and welfare ...." Both laws have been implemented by the promulgation of rules by responsible federal agencies, including the established criteria noise levels by EPA. These criteria have been widely accepted and are being incorporated into noise regulations being developed by state and local governments. Consequently, although noise impact analysis will not receive major emphasis in this TA, selected impacts which are subject to regulation and which may become issues will be analyzed.

B. Baseline Data

Data needs include: identification of noise sources and levels, local and state regulations applicable to the scenarios, location and size of human and animal populations in relation to noise sources and levels, and transportation modes and locations.

Sound pressure level spectra associated with operation of various equipment such as compressors, pumps, coal-crushers, conveyor systems, etc., will be required for assessing plant-generated noise. Other data on transportation activity such as railway operations will be needed to analyze the impact of radiated noise from this source.

Analysis of transportation and social, economic, and political impacts will provide additional and supporting data. Some ambient air and topographic data will be available from the scenario descriptions and the air impact analyses.

C. Methods and Procedures

The noise impact analysis will address the effects of noise associated with the various technologies including: mining, energy processing, and transportation. The following sections identify the procedures used to estimate noise levels and describe criteria used to predict effects.

1. Estimating Noise Levels

Based upon numerous laboratory and field studies, quantitative noise level values can be related to effects on humans. Some 20 different measures of noise have been developed and are used in practice. These measures, based on laboratory and field studies, make it possible to relate noise levels to effects. A particular measure is generally adopted to satisfy the specific objectives of a noise evaluation program.

To assess the impact of noise quantitatively, EPA recommends the use of the measure L_{dn}. This measure accounts for differences between human response to noise at night and during the day. Mathematically it is expressed:[1]

$$\text{(1)} \quad L_{dn} = 10 \log \frac{1}{24} \left[15 \left(10^{L_d/10}\right) + 9 \left(10^{\frac{L_n + 10}{10}}\right) \right] \text{ dB}$$

where

(2) L_{eq} = the long-term equivalent of A-weighted sound levels (24 hours for this TA).

(3) $L_d = L_{eq}$ for daytime (0700 hours to 2200 hours)

(4) $L_n = L_{eq}$ for nighttime (2200 hours to 0700 hours)

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[1] Mathematical explanation of equations is as follows:

L_{dn} = day-night level $\quad$ L_n = night level

L_d = day level $\quad$ dB = decibel

L_{eq} = equivalent level

As shown in this expression, the impact of sound is not the same during the day and at night. To be equivalent, nighttime levels must be 10 dB lower. It will be assumed that the noise evaluated is equal to that exceeded 50 percent of the time.[1]

In this study, noise levels will be predicted using a simple model that incorporates information on ambient air and topographic conditions, and the properties of energy dispersion in air media under these conditions. The results of this model predict energy levels at selected distances from single or multiple sources.

Some cases will be studied in detail to ascertain the degree of expected impact from mining, processing, and transportation. The results of these studies will be evaluated in terms of the criteria for assessing noise levels discussed below.

2. Criteria for Noise Level Assessment

In this study, human and wildlife responses to noise will be estimated using EPA documentation.[2] Some of the factors useful

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[1]The equivalent sound level for a normal statistical distribution can be described in terms of its mean value, which for a normal distribution is the noise level that is exceeded 50 percent of the time (L_{50}) and the standard deviation (S) of the noise level distribution is $L_{eq} = L_{50} + 0.115\ S^2$.

[2]Environmental Protection Agency, Office of Noise Abatement and Control (1974) Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety. Washington: Environmental Protection Agency.

in assessing and describing the effects of predicted noise levels are presented in the following two subsections.

a. Human Responses: Table 4-3 summarizes noise level limits in terms of L_{dn} and L_{eq} considered essential to protect public welfare and safety. Note that L_{dn} = 55 dB and L_{eq} = 55 dB are values that are representative of most conditions around power plants. For more detailed characterizations, the EPA "levels" document will be consulted. This table serves as the basis for general assessment of environmental noise as required by this program. Further refinement of these can be achieved by considering the factors discussed below.

TABLE 4-3: SOUND LEVELS REQUIRED TO PROTECT PUBLIC HEALTH AND WELFARE

Effect	Level		Area
Hearing loss	$L_{eq(24)}$	$\leq$70 dB	All areas
Outdoor activity interference and annoyance	L_{dn}	$\leq$55 dB	Outdoors in residential areas and farms and other outdoor areas where people spend widely varying amounts of time and other places in which quiet is a basis for use
	$L_{eq(24)}$	$\leq$55 dB	Outdoor areas where people spend limited amounts of time, such as school yards, playgrounds, etc.
Indoor activity interference and annoyance	L_{dn}	$\leq$45 dB	Indoor residential areas
	$L_{eq(24)}$	$\leq$45 dB	Other indoor areas with human activities such as schools, etc.

Source: Environmental Protection Agency, Office of Noise Abatement and Control (1974) Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety. Washington: Environmental Protection Agency.

The ability to communicate effectively depends upon the presence and level of ambient or "masking" noise. The values of Table 4-4 illustrate the person-to-person separation that will permit 95 percent speech intelligibility in the presence of different A-weighted sound levels and vocal efforts. The data are representative of male voices with individuals face-to-face outdoors.

TABLE 4-4: SOUND LEVELS PERMITTING SPEECH COMMUNICATION

Listener Distance (feet)	Ambient Sound Level for Speech Communication (Decibels A-Weighted)			
	Low Voice	Normal Voice	Raised Voice	Very Loud Voice
1	60	66	72	78
2	54	60	66	72
3	50	56	62	68
4	48	54	60	66
5	46	52	58	64
6	44	50	56	62
12	38	44	50	56

Source: Tracor, Inc. (1973) Guidelines on Noise. Washington: American Petroleum Institute.

Additional evaluation may be made by considering the effect of noise upon communications by telephone. The quality of telephone usage in the presence of steady-state masking noise may be obtained from Table 4-5.

The change in ambient sound level is an important factor in assessing the impact from added noise sources. It is possible to just detect a two to three dBA change while a five dBA is readily apparent. A 10-dB increase is judged by most people as a doubling of the loudness of sound and each 10-dB increase impresses a listener as doubling the loudness.

TABLE 4-5: QUALITY OF TELEPHONE USAGE IN THE PRESENCE OF STEADY-STATE MASKING NOISE

Noise Level (dBA)*	Telephone Usage
30 to 50	Satisfactory
50 to 65	Slightly Difficult
65 to 75	Difficult
Above 75	Unsatisfactory

*decibels A-weighted

Source: Tracor, Inc. (1973) Guidelines on Noise. Washington: American Petroleum Institute.

b. Wildlife Responses: The effects of noise upon wildlife and domestic animals are not well understood. Studies of animals subjected to varying noise exposures in laboratories have demonstrated physiological and behavioral changes and it may be assumed that these reactions are applicable to wildlife. However, no scientific evidence currently correlates the two.

It is known that large animals adapt quite readily to high sound levels. Conversely, it has been demonstrated that loud noise disrupts broodiness in poultry and consequently can affect egg population.

The major effect of noise on wildlife is related to the use of auditory signals. Acoustic signals are important for survival in some wildlife species. Probably the most important effect is related to the prey-predator situation. The effectiveness of an animal that relies on its ears to locate prey and that of an animal that relies on its ears to detect predators are both impaired by intruding noise.

In addition, the reception of auditory mating signals could be limited and, therefore, affect reproduction. Distress or warning signals from mother animals to infants (or vice versa) or within groups of social animals could be masked and possibly lead to increased mortality. There are clues that short-term high noise level may startle wild game birds and stop the brooding cycle for an entire season.

D. Anticipated Results

Results will be presented in simple terms, based on L_{dn} for environmental noise and A-weighted sound for occupational noise. These results will be interpreted in reference to applicable federal, state, and local regulations. As shown in Figure 4-1, results of predicted noise levels can be related to expected human response.

E. Data Adequacy

Noise technology is developing rapidly, both in regulation development and noise assessment methodologies. Contact will be maintained with EPA's Office of Noise Abatement and Control, the Department of Labor, the Bureau of Mines, and federal agencies with noise responsibilities to insure that the analyses made in this TA are based on the best available data.

Approximate acoustical emissions in terms of frequency and character from mining, processing, and transportation elements are likely to be difficult to identify and acquire. Manufacturers of such systems will be contacted in efforts to obtain the necessary noise descriptions. Where data are not available, extrapolations based on data for similar equipment will be made.

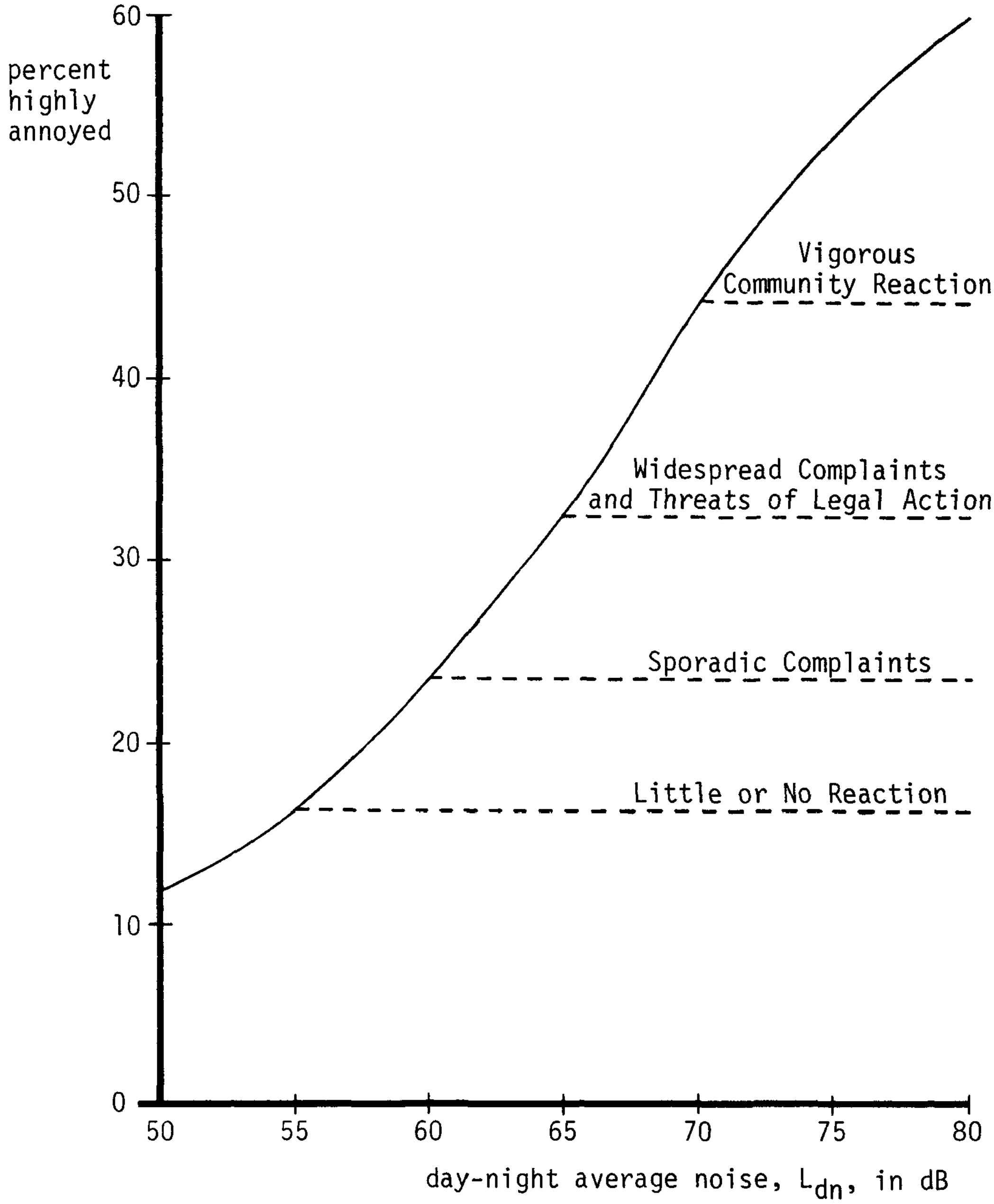

Figure 4-1: Expected Day-Night Human Responses at Various Noise Levels

Source: Crocker, Malcolm J., and A. John Price (1975) Noise and Noise Control. Cleveland: CRC Press, 2 vols.

F. Research Adequacy

Certain simplifications and fundamental methodologies for assessing the noise impacts are developed and available. However, additional research is required for assessing the increase of community noise levels as functions of growth of a community.

Population increases in development areas will cause a corresponding increase in noise levels. The character and degree of impact on community noise levels as a function of population is currently under study by EPA's Office of Noise Abatement and Control. When available, results of this research will provide the basis against which to predict changes in community noise fields.

4.3 RESOURCE AVAILABILITY

Western energy development is taking place during a period of increased competition for a wide range of resources, including water, land, transportation, materials, personnel, and financial resources. The consumption or change in the availability of these resources due to energy development can produce major impacts. Descriptions of changes in resource availability will provide information needed in impact analyses in a number of categories, especially the ecological, social, economic, and political analyses. The following sections describe the general approach that the research team will use in providing data for these analyses and helping identify and define resource availability issues.

4.3.1 Water[1]

A. Introduction

The results of an assessment of changes in surface and groundwater availability will be an essential for ecological, social, economic, political, and policy analysis. Water is an especially crucial resource because of: (1) process water requirements of many of the technologies; (2) water compacts, either existing or being negotiated, which have influenced the balance of power between localities, states, and larger areas; and (3) rapidly diminishing groundwater supplies in some parts of the West.[2]

The parameters used in this analysis to identify local and regional water availability issues, both those already identified and those which might be identified by this TA, are as listed.

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[1]Available water is defined for purposes of this study to mean water that is physically available. The question of whether water is legally available will be addressed only generally except at selected sites and areas.

[2]Hundley, Norris Jr. (1975) Water and the West: The Colorado River Compact and the Politics of Water in the American West. Berkeley: University of California Press.

1. Ambient Conditions (Surface Water)

    a. flow
    b. depletions
    c. return flows

2. Present and Projected Water Needs

    a. municipal
    b. industrial
    c. agricultural
    d. energy

3. Future Watershed Management

    a. planned flow regulation and storage
    b. reallocation of presently allocated water
    c. state water plans
    d. changes in surface water flow as a consequence of energy developments

4. Groundwater Sources

    a. existing data on location, extent, reliability, and flow
    b. adaptability of water to conjunctive use
    c. changes in flow and recharge from energy use

The analysis of water availability will be primarily concerned with two topics: instream flow and process needs. The analysis of instream flow will consist of both a baseline description of the existing conditions and an analysis of the flow changes caused by scenario developments. A discussion of the instream flow requirements for aquatic biota will also be a part of this analysis. This latter discussion is especially applicable in states such as Montana, where the Montana Water Use Act of 1973 permits water to be reserved for instream flow.

Analysis will be made at two levels. First, at the site-specific level, a conceptual scheme will be presented to supply water to the particular process or group of processes under consideration. This may include aqueducts, pipelines, and possibly new storage reservoirs; or perhaps as little as an intake structure in the near vicinity of the plant. At this level of analysis, no specific attempt will be made to draw a connection between the site-specific scenario under investigation and other possible developments, either upstream or downstream.

A second level of analysis will address an aggregate level of development where several scenarios will interact and compete for the available water. Where possible, higher order water requirements for municipalities, agriculture[1] and secondary industry will also be analyzed in the evaluation of water impacts.

Water laws and compacts will be addressed, as they create restrictions on water availability, either in an absolute or distributive sense. Water availability restrictions will also include such issues as the instream need to support aquatic biota or to maintain wild and scenic rivers, and to sustain the assimilative capacity of the watercourse to accept waste streams.

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[1]Anderson, Mark H., and others (1973) The Demand for Agricultural Water in Utah. Logan, Utah: Utah State University, Utah Water Research Laboratory.

B. Baseline Data

Data needs for the site-specific scenarios include data on the natural stream flows, groundwater resources, and process water requirements for the scenarios, as well as water requirements associated with the increase in population. Aggregated scenarios require, in addition, data on water requirements for the expansion of agriculture and the development of related secondary industries.

Baseline data will generally be presented as ranges, both with relation to stream flow and water requirements. To decrease the complexity associated with an analysis involving large numbers of approximate variables, a base case will be analyzed where the water requirements of the site-specific scenarios will be varied only with respect to construction requirements and operational requirements as they apply to the different processes under consideration. (Process water requirements will be determined for each scenario, drawing on data included in the various ERDS.)

Following this base case analysis, a sensitivity analysis will be made addressing variations in process water needs. As an example, the base case for a power plant cooling system assumes a wet, mechanical draft cooling tower. Alternatives to this cooling system include cooling ponds (modified once-through cooling)[1], wet towers utilizing natural draft, dry cooling towers

[1] Once through cooling is no longer allowed by law except in the case of a Section 316(a) exemption to 40 CFR 122.

(no evaporative loss, heat transfer from air blown over tubes), and wet-dry towers (a combination of wet and dry configurations). These alternatives would each have a different effect on the water requirements of the power plant cooling system (the largest water consuming system in a conventional coal-fired, steam-electric power plant). Similarly, alternative internal water use schemes will be investigated for other processes included in the scenarios; and a water-use sensitivity analysis will be performed.

Additionally, some of the more obvious changing water needs, such as water requirements for reclamation, will be varied seasonally or as otherwise appropriate. Instream water flow rates will be obtained from the existing literature, including the standard USGS Surface Water Records and the results of previous studies concerned with water availability determinations.[1] The combination of these two sets of data (process requirements and in-stream flow) will indicate critical areas in water availability.

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[1]Department of the Interior, Bureau of Reclamation (1975) Westwide Study Report on Critical Water Problems Facing the Eleven Western States; and Department of the Interior, Water for Energy Management Team (January 1975) Report on Water for Energy in the Northern Great Plains Area with Emphasis on the Yellowstone River Basin; and Department of the Interior, Water for Energy Management Team (1974) Report on Water for Energy in the Upper Colorado River Basin; and Northern Great Plains Resources Program, Water Work Group (1974) Water Work Group Report. Denver: Northern Great Plains Resources Program.

C. Methods and Procedures

Possible water sources will be determined for the site-specific scenarios. These can be surface water, groundwater, or both. The impact on these sources as a consequence of meeting process water requirements for the postulated development will be determined. Whenever possible, the entire site-specific scenario will be modeled as though it places a single water demand on the hydrologic system. There will be several constraints on the water supply system that may affect the availability of water for use in the scenarios. These competing demands will be in the form of other user requirements as expressed by existing water rights, as well as more undefined demands such as instream needs for aquatic biota and for the maintenance of wild and scenic rivers. These water use constraints will generally be identified in the analysis of the three aggregate scenarios.

Generally, the analysis of water availability at the site-specific level will consist of hand calculations relating a variety of localized flow parameters such as the seven day-ten year low flow, minimum flow, average flow, and the yearly flow pattern to the site-specific water requirements. In some cases, there will not be sufficient existing data to extract these values. A detailed watershed analysis might have to be performed to obtain these data. If this situation develops during the first year study, a more detailed watershed analysis might possibly be completed in the second and third years. However, this TA is not intended to include extensive field research.

Efforts will be made to compile and present available information related to groundwater availability in both the UCRB and UMRB. This potential water supply source is the focus of several current studies (for example, by the Old West Regional Commission, Peabody Coal Company, the Surface Environment and Mining [SEAM] Program, USGS, EPA, Health, Education and Welfare, Bureau of Land Management, Montana Bureau of Mines and Geology, the Office of the Wyoming State Engineer, South Dakota Geological Survey, and Western Energy Company) and may be of significance to western energy resource development. The interbasin transfer of water will also be discussed, along with the effect of river basin compacts on state allocation values of local water.

At the aggregate analysis level, there are existing numerical models that have been developed for the river basins under consideration. When of significant benefit to the TA to have unique computer analyses performed, an effort will be made to utilize these models in cooperation with developers. The following descriptions provide more specific information about numerical models that might be used within the two river basin areas:

1. Upper Missouri River Basin (UMRB)

a. Existing Programs

(1) HYD-2, Generalized Computer Reservoir Operation Studies.[1] This computer program was developed by the Bureau of Reclamation and incorporates the instream water needs criteria of the Bureau of Sports Fisheries, and Wildlife. The model uses streamflow data and user requirements as input and adjusts runoff to obtain upstream effects on water availability. The Northern Great Plains Resource Program used this program.

(2) EDP Program 724 C0100, Missouri River Main Stem Reservoirs Long-Range Regulation Studies, Corps of Engineers.[2] This program models the management of the six main stem reservoirs on the Missouri River. The operation of tributary reservoirs is not considered, but must be taken into account in the program input. This program has previously been used by the Corps to predict water flow impacts associated with different levels of energy development activity.[3] The program operates on monthly average values for both streamflow and reservoir releases from the six main stem reservoirs: Fort Peck, Sakakawea, Oahe, Sharpe, Francis Case, and Lewis and Clark.

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[1] Northern Great Plains Resource Program, Water Work Group (1974) Water Work Group Report. Denver: Northern Great Plains Resource Program.

[2] Department of Defense, Army, Corps of Engineers, Missouri River Division (n.d.) Missouri River Main Stem Reservoirs Long Range Regulation Studies. Omaha, Neb.: Corps of Engineers, Missouri River Division.

[3] Department of Defense, Army, Corps of Engineers, Missouri River Division (1974) Missouri River Main Stem Reservoir Regulation Studies, Series 1-74. Omaha, Neb.: Corps of Engineers, Missouri River Division.

b. Programs Under Development

(1) Montana State University is currently developing a water model of the Yellowstone River Basin that will have some water flow modeling capabilities.[1]

(2) The Department of Natural Resources, State of Montana, is currently developing a flow model of the Yellowstone River Basin. As noted in the water quality discussions, the model is expected to be calibrated beginning 1 January, 1976 and should be available for basin simulations by 1 July, 1976.

2. Upper Colorado River Basin (UCRB)

a. The Bureau of Reclamation has several models of the Upper Colorado.[2] Principal among these are:

(1) The Colorado River Storage Project Model (CRSP) is used primarily for preparing monthly operating plans for the existing system, and secondarily for assessment of future water requirements for planning purposes.

The CRSP Model is limited because it is designed as an operations model. It will not describe individual project effects on tributaries to the main stem Colorado River; however, it will show their downstream effects. It is neither convenient nor practical to add new features or additional parameters to the model.

(2) The Colorado River Simulation Model (CRSM) is a more comprehensive model being developed for use on a wide range of problems in the planning, utilization, and management of Colorado River water resources. It is described more fully in Section 4.2.2.

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[1]Van Voast, Wayne A., and others (n.d.) Strip Coal Mining and Mined Land Reclamation in the Hydrologic System, Research Proposal. Billings, Mont.: Montana Bureau of Mines and Geology.

[2]Huntley, Charles W. (1975) "Hydrologic Models Used in the Colorado River Basin." Presented at the U.S.-U.S.S.R. Group, Planning, Utilization and Management of Water Resources, Dec. 8-9. Unpublished paper, Denver, U.S. Bureau of Reclamation.

(3) The Return Flow Prediction Model[1] is a comprehensive tool for predicting quantity and quality. This model was also described in the section on water quality impacts.

b. Several hydro-salinity models are available including the Hydro-Salinity Model of Utah State University[2] and the University of Colorado Hydro-Salinity Model.[3] The University of Colorado model is a digital computer adaptation and extension of an analog computer model developed by M. Leon Hyatt and others at Utah State University.

Both of these models address flow and salinity. They are described in the water quality impacts analysis section.

c. The CORSIM Project has developed a computerized numerical model which relates flow and water rights.[4] The project has been funded by ten oil companies, three water districts, two utilities, and one industry to identify water availability under critical flow conditions and high water demand. When water becomes so scarce that the water use structure changes from casual use to strict adherence to issued water rights, the availability patterns may also change.

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[1]Shaffer, Marvin J., and Richard W. Ribbens (October 1974) Generalized Description of a Return Flow Quality Simulation Model. Denver: Department of the Interior, Bureau of Reclamation, Engineering and Research Center.

[2]Hyatt, M. Leon, and others (1970) Computer Simulation of the Hydrologic-Salinity Flow System within the Upper Colorado River Basin. Logan, Utah: Utah State University, Utah Water Research Laboratory.

[3]Howe, Charles W. (1975) Primary and Secondary Impacts of Energy Development in the Gunnison River Area, the Hydro-Salinity Model Appendix, Draft Report. Boulder, Colo.: University of Colorado.

[4]Fleming, David E. (November 1975) "The CORSIM Project." Presented at Annual Meeting of the American Society of Civil Engineers, Denver, Colo.

D. Anticipated Results

The water availability study will use the site-specific and aggregate scenarios as tools to help identify and define issues related to water as a physical resource. The intermediate analyses which lead to the identification of issues produce several outputs, among which are:

1. Graphs which indicate flow relationships at specific locations within the river basins;
2. Tables that indicate the use of water upstream of the locations analyzed in 1 above.
3. A discussion of the legal and social controls that affect the allocation and use of water;
4. Schemes for meeting water demands in the various energy development areas;
5. An identification of the water-related impacts associated with the supply of water;
6. An evaluation of the impacts identified as a result of all of the above steps; and
7. A sensitivity analysis relating process water requirements (internal water reuse analysis) to environmental effects.

These intermediate outputs will then be discussed in the context of the issues that are raised either by the analysis or through contact with the people in the western area. The identification of issues related to water availability will provide input into the policy analysis of the alternative actions available to the decisionmaking process.

E. Data Adequacy

The base data that will be used to provide some of the intermediate outputs of this analysis will come from a variety of sources, which include the U.S. Geological Survey, Bureau of Reclamation, Corps of Engineers, state geological survey offices, and state water resources offices.

Data collected from the above sources has been compiled in a form similar to some of the proposed intermediate outputs of this study by several organizations, including those mentioned above. These previous data compilations and analyses[1] will provide an adequate information base for some of the scenarios used in this TA. However, in some cases, the data available

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[1]Department of the Interior, Bureau of Reclamation (1975) Westwide Study Report on Critical Water Problems Facing the Eleven Western States; Department of the Interior, Water for Energy Management Team (1974) Report on Water for Energy in the Upper Colorado River Basin; Northern Great Plains Resources Program, Water Work Group (1974) Water Work Group Report. Denver: Northern Great Plains Resources Program; Federal Energy Administration (1974) Project Independence Blueprint; Final Task Force Report: Water Requirements, Availabilities, Constraints, and Recommended Federal Actions, prepared by the Water Resources Council. Washington: Government Printing Office; National Petroleum Council, Committee on U.S. Energy Outlook, Other Energy Resources Subcommittee, Water Availability Task Group (1973) U.S. Energy Outlook: Water Availability. Washington: National Petroleum Council; Davis, George H., and Leonard A. Wood (1974) Water Demands for Expanding Energy Development, U.S. Geological Survey Circular 703. Reston, Va.: U.S. Geological Survey; Department of the Interior, Water for Energy Management Team (January 1975) Report on Water for Energy in the Northern Great Plains Area with Emphasis on the Yellowstone River Basin; and Western States Water Council (1974) Western States Water Requirements for Energy Development to 1990. Salt Lake City: Western States Water Council.

will not be as pertinent to this TA as would be desired. In these cases, data shortages will be indicated within the TA. The importance of water data related to western energy development has been recognized by federal, state, and private groups. The activities of these organizations should insure that current data shortages are reduced either with respect to water as a resource or with respect to the requirements of the new technologies.

F. Research Adequacy

Water has been identified as one of the more significant issues concerning energy resources development in the West. The continued emphasis on water-related problems in the western states will insure that additional research is conducted in this area. Since 1970, a number of major inputs have been made into the understanding of western water problems. Currently, in the UMRB, 11 projects have been identified related to surface water flow and 24 related to groundwater.[1] Similar research projects are being identified for the UCRB. EPA's Region VIII office has at least 18 research projects underway in various states related to water problems and energy development. One EPA headquarters request for proposal has been identified in the strict water

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[1]Old West Regional Commission and Department of Agriculture, Forest Service (1975) Energy Research Information Service (ERIS) Quarterly Report 1 (November).

availability area.[1] Most current research is identifying problems associated with various stages of western energy development. Each of these studies independently defines the relationship of energy or water demand to time. It is unknown at this time whether these various data bases can be combined and used, either in a valid comparison or in a compilation of predictive data.

The research outlined above would seem to greatly reduce present data deficiencies for this TA; however, until the outputs of these studies can be evaluated, it is difficult to say that the goal of the research will be achieved. Therefore, although some areas of current data deficiency, such as groundwater resource evaluations, are being researched, until those studies are made available it would be premature to say that the total research need has been fulfilled. Specific research needs will be identified as the TA progresses.

4.3.2 Land Consumption

A. Introduction

In the first year TA, the analysis of land as a resource that will be consumed during energy development will emphasize the identification of lands that are available for development

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[1] Environmental Protection Agency (1975) "Optimizing Wet/Dry Cooling Towers for Water Conservation and Plume Abatement," Request for Proposal CI75-0145. Contractor: United Engineers and Construction, Inc., Philadelphia.

and their adequacy and suitability for meeting development needs. These latter considerations include, in addition to the energy developments themselves, the lands that will be required to support population increases and secondary industrial and commercial development within the region.[1]

B. Baseline Data

A baseline of land use and ownership data from the early 1970's will be used. In part, the availability of data dictates this choice, since the most recent regionwide land use maps, such as those used in the Missouri, Upper and Lower Colorado Comprehensive Framework Studies,[2] were published during those years. Moreover, the exploitation of energy resources had not reached a significant level in most regions during this period. Lands committed to energy resource development during or prior to this period will be considered part of the existing baseline.

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[1] Land use as an impact category is discussed in the social, economic, and political impacts section of this chapter. Section 6.4, the ecological impacts section, includes a discussion of land consumption impacts which have ecological consequences.

[2] Missouri River Basin Interagency Committee (1971) Comprehensive Framework Study, Missouri River Basin; Upper Colorado Region State-Federal Interagency Group (1971) Upper Colorado Region, Comprehensive Framework Study; and Pacific Southwest Interagency Committee, Lower Colorado Region State-Federal Interagency Group (1971) Lower Colorado Region Comprehensive Framework Study.

In compiling the data base, predictions of land requirements will include planned or announced energy-related developments, as well as related projects such as the extension of irrigation systems. Urban and suburban land consumption will be projected, based on cumulative population growth estimates made in the section on social, economic, and political impacts.

C. Methods and Procedures

The major tasks involved in this analysis are to identify and quantify present and projected land requirements, determine what lands are available, and to assess their suitability. Designations will include land ownership and will indicate lands used for:

- Energy resource development
- Secondary industrial and commercial development
- Urban or residential development
- Pasture, cropland, and recreation
- Wildlife habitat or barren lands

Maps are to be prepared for both the site-specific and regional scenarios.

A certain amount of geographic focus may be supplied by a preliminary survey of the suitability of land for different purposes. This survey will note flood plains, ecologically sensitive areas, restricted government lands, and any other areas where extreme social pressure, laws, or regulations would prohibit facilities construction. Thus, it may be possible at the local level to present maps illustrating the major outlines of land use during the 1980's and 1990's. Due to the sparsely settled nature of the West, mapping by elimination will be employed. Land restricted from use will be blocked out.

D. Anticipated Results

The product of the land availability analyses will relate land requirements to land availability both for the site-specific and aggregated scenarios. This will help identify those sites or areas where issues are likely to arise because of (1) environmental sensitivity; (2) state and federal parks, forests, nature preserves, etc; and (3) flood plains.

E. Data Adequacy

Input data for this part of the TA will come largely from existing planning documents. The river basin framework plans contain existing land use maps and discussions at the level of the subbasin.[1] Included in these plans are anticipated changes in land commitments and the capabilities of lands to accommodate

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[1]Missouri River Basin Interagency Committee (1971) Comprehensive Framework Study, Missouri River Basin; Upper Colorado Region State-Federal Interagency Group (1971) Upper Colorado Region, Comprehensive Framework Study; and Pacific Southwest Interagency Committee, Lower Colorado Region State-Federal Interagency Group (1971) Lower Colorado Region Comprehensive Framework Study.

certain types of uses. These plans have often been made without taking into account the levels of energy development now envisioned. However, they provide the best regionwide predictions of changes in nonenergy-related land use and availability.

In many areas, state and federal level land use plans disaggregated to a more local scale are available. The Bureau of Land Management makes comprehensive management plans for the lands under their jurisdiction at the district and unit level. Land use plans have also been developed for some national forests. State parks and recreation departments also have their own plans, as do many counties (for example, Washington County, Utah) and towns (for example, Farmington, New Mexico).

F. Research Adequacy

Development patterns can be predicted with somewhat more accuracy where zoning is indicated in city or county development plans. Unfortunately, not much of this type of analysis is appropriate to the scenarios in this TA. The difficulty with integrating existing outlooks and forecasts lies in the fact that they represent assumptions not used in this study.

Additional efforts are needed in this area. Programmatic and regional environmental impact statements are one example of the types of studies that can be used to compile the required data and to do the kinds of analyses that are needed to inform this TA.

4.3.3 Transportation

A. Introduction

The adequacy of existing transportation systems for moving energy, materials, and equipment for energy resource development is already being discussed as a major issue.[1] Transportation needs also define important variables that must be taken into consideration in assessing ecological, social, economic, and political impacts. For example, issues have either already been identified or are likely to arise in connection with slurry pipelines, subsidizing some modes of transportation, and environmental and aesthetic impacts, particularly those required for electrical transmission corridors.

The analyses of transportation availability impacts will utilize a variety of parameters to assess the new demands on transportation systems, including:

1. capacity of existing transportation facilities;
2. routes of existing facilities;
3. state of repair and maintenance of existing facilities; and
4. availability of equipment to meet transportation demand.

The major transportation carriers under consideration include pipelines (liquid, gas, and coal slurry), high-voltage electrical

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[1]National Academy of Engineering, Task Force on Energy (1974) U.S. Energy Prospects: An Engineering Viewpoint. Washington: National Academy of Sciences.

transmission lines, and coal rail transport. Although it is recognized that existing transportation facilities are probably inadequate for projected western energy exports, they are the most likely means for expeditiously and economically transporting much of this increased production.

B. Baseline Data

Existing transportation facilities in the western energy resource states will be identified and described. Emphasis will be placed on both the transportation links located in the western states and interconnecting links which facilitate supply to the nation's demand centers. Specific data requirements include:

1. routes and geographical proximity to projected energy development sites;
2. current and projected utilization;
3. capacity (for example, tonnage for railroads) or throughput (for example, barrels per day for liquid pipelines);
4. potential for tie-in via lateral lines; and
5. present condition (that is, how well maintained are they).

Requirements for facilities to transport energy in various forms from the West to consumption centers outside the West will be determined for the aggregated scenarios using the energy models described in Chapter 3. These transportation facility requirements will be filled by a combination of existing systems (where possible) and new facilities. An examination of existing transport locations and types of facilities will provide data on the extent to which they can be used. Utilization of existing facilities will almost certainly require pipeline laterals or feeders and railroad spurs with track upgrading. Since long distance electrical transmission lines are constructed to transmit electricity from a specific plant, new electrical transmission corridors will generally be required to transmit electricity from projected developments.

C. Methods and Procedures

The transportation analysis will include three tasks:

1. determination of western transportation requirements as specified from the scenarios;
2. specification of required new transportation facilities; and
3. identification of certain impacts associated with new transportation facilities.

Requirements for new transportation facilities will be identified by comparing existing facilities identified in obtaining baseline data and projected needs. Requirements for these new facilities will be delineated in terms of length of new tracks, pipelines, and transmission lines, and land availability.

Other impacts or requirements of interest will be identified by quantifying facilities needed for additional capacity. For example, what is the number of new rail cars required to carry the coal tonnage and how does this compare with rail car production capacity? What are total steel requirements and how do they compare with the industry's production capacity? What are the total land requirements for new transportation facilities?

D. Anticipated Results

Descriptions of potential requirements for transportation facilities will be by transportation mode categories and appropriate units such as hopper cars, miles of transmission lines, rails or pipe, rights-of-way, land consumption, and the magnitude of these requirements will be compared against current production and potential future production efforts. Where appropriate, maps will indicate new requirements in the transportation system. Aesthetic impacts of electrical transmission lines, noise impacts from increased rail traffic, and other specific impacts will also be presented. These results, together with the results of economic analysis, will support the analysis of resource availability as a potentially major policy issue.

E. Data Adequacy

Data sources will include recently conducted national surveys on transportation networks and also, where available, information from the individual agencies or companies presently managing this system. Major data sources include: the Department of Transportation; the Department of the Interior; the Federal Power Commission; the National Petroleum Council; the American Gas Association; the Edison Electric Institute, and the U.S. Railway Association, as well as trade journals.

Although some data have been obtained, it is not now known whether sufficient data will be available to detail the existing transportation conditions.

F. Research Adequacy

Although transportation is recognized to be an important aspect of energy supply to demand centers, it appears at the present time that little effort has been made (except for the Project Independence Study) to analyze requirements commensurate with the western energy resources development. Thus, the transportation issue can be identified as one for which additional research efforts should be expended.

Since transportation costs can represent a significant portion of energy prices, a comparative economic study of alternate transport mode costs for specific routes emanating from the western region would supply useful information for policy analysis. An extension of this analysis would be a linear programming analysis which minimizes transport cost of energy out of the western region.[1]

4.3.4 Materials and Equipment

A. Introduction

A variety of materials and equipment are required as input for the scenarios. For example, one anticipated material requirement is the amount of steel required for plant construction. It is conceivable that the amount of steel required will be a significant portion of the nation's steel output. Western energy development, therefore, would compete with other sectors for available steel. This might slow down deliveries, drive up prices, and lead to an expansion of steelmaking capacity. The demand for these inputs will be discussed and the direct impact of these demands on the available market will be analyzed. Secondary impacts such as energy requirements to produce the required steel will only be discussed qualitatively. The total analysis will have a direct relationship with scheduling the construction and operation of new facilities. In order for this TA to reflect a realistic scheme for western energy development, an analysis of

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[1] Both are beyond the scope of work for the TA, but are being considered among the supporting projects to be funded by EPA.

the supply of the necessary tools for that development must be made.

B. Baseline Data

The variety of materials and equipment required are specified in the scenario descriptions and ERDS data base. Inventories and production capacity data will be gathered from national economic data bases to include relevant production categories. Where available more specific data will be obtained from local sources. The Strategic Environmental Assessment System (SEAS)[1] data base also contains information on materials availability. Some major categories of baseline data are indicated in Table 4-6.

C. Methods and Procedures

Material and equipment input resources will be itemized and the number of individual items and required delivery times will be estimated. From this compilation a comparison can be made with supply inventories in local, regional and national markets. A further analysis would indicate the extent of the competition for these items and the impacts that this competition would have on the projected development times. An important input into this

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[1]Booz, Allen and Hamilton, Inc. (1975) Strategic Environmental Assessment System. Developed under Environmental Protection Agency Contract No. 68-01-2942 by Booz, Allen and Hamilton, Inc., Bethesda, Md.

TABLE 4-6: SELECTED MAJOR MATERIALS AND EQUIPMENT RESOURCES REQUIRED FOR CONSTRUCTION OF ENERGY FACILITIES

Resource	Units
Refined products	Tons
Cement	Tons
Ready-mixed concrete	Tons
Pipe and tubing:	
Less than 24-inch diameter	Tons
24-inch diameter and greater	Tons
Oil country tubular goods	Tons
Steel forgings	Tons
Iron and steel castings	Tons
Structural steel	Tons
Rebar	Tons
Valves--24-inch diameter and greater	Units
Valves--24-inch diameter and greater	Tons
Steam turbogenerator sets	1,000 horsepower
Steam turbines without generators	1,000 horsepower
Gas turbogenerator sets	1,000 horsepower
Gas turbines without generators	1,000 horsepower
Draglines	Cubic yards
Draglines	Tons
Drill rigs	Item-years
Pumps and drivers--greater than 100 horsepower	Items
Pumps and drivers--greater than 100 horsepower	Tons
Compressors and drivers--greater than 1,000 horsepower	Items
Compressors and drivers--greater than 1,000 horsepower	Tons
Heat exchangers	1,000 $foot^2$ surface
Pressure vessels--greater than 1-1/2 inch plate	Tons
Boilers	Million-Btu per hour

total analysis process will be results of a unified numerical model developed by Bechtel.[1] The results obtained using Energy Supply Planning Model will provide valuable assistance in scheduling equipment requirements.

D. Anticipated Results

The major materials and equipment input items for the patterns of development included in our scenarios will be identified and evaluated as to their availability in light of the demands for similar input requirements by other activities. Among the items that will be considered are the materials (and equipment) for:

1. exploration (drill rigs);
2. construction (cranes, welding machines, earth-moving equipment, draglines, etc.);
3. processing facilities (see Table 4-6); and
4. operating supplies (catalysts, chemicals, maintenance materials, etc.).

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[1] Carasso, M., J.M. Gallagher, K.J. Sharma, J.R. Gayle, and R. Barany (1975) The Energy Supply Planning Model. San Francisco: Bechtel Corporation.

E. Data Adequacy

Sources of information include published reports of material and equipment required by prospective plant owners for the processes included in the scenarios, by the ERDS and also by major engineering and construction contractors such as C.F. Braun and Company.[1] Recently published generalized reports are expected to provide updated lists periodically. In addition, specific individual plant data are sometimes available.

F. Research Adequacy

Research on equipment and material availability has been limited.[2] Some requirements areas have not been addressed. The existing capacity and potential for increasing capacity of equipment and materials suppliers is not well known. The market structure is world wide, but limited in the number of participants, both as buyers and sellers. How this system responds to new participants, or increased demand for products is poorly understood. The important questions of whether increased production is possible,

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[1]Howell, Richard D. (1974) "Mechanical Design Considerations in Commercial Scale Coal Gasification Plants," in Proceedings of Sixth Synthetic Pipeline Gas Symposium, Chicago, October 28-30. Washington: American Gas Association.

[2]Federal Energy Administration (1974) Project Independence Blueprint; Final Task Force Report: Availabilities, Requirements, and Constraints on Materials, Equipment, and Construction. Washington: Government Printing Office.

and what conditions must be satisfied for it to occur, need to be addressed.

4.3.5 Personnel Availability

A. Introduction

Personnel availability impact analyses will examine the labor requirements for development of energy resources. Impacts to be addressed include those which fall on locally recruited workers, local people not directly recruited, immigrants, and labor unions.[1] All of these impacts are either already or potentially the source of policy issues that will affect western energy development.

B. Baseline Data

Baseline data on personnel requirements are compiled in the scenario and ERDS descriptions. As stated in Section 3.2, these data are derived from several published sources, including two products of S&PP and Radian.[2] Others were independently produced.[3] The Bechtel model discussed in the previous section is expected to be a particularly important data source for the personnel analysis.

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[1] There are numerous overlaps between the impacts to be discussed in this section and in the social, economic, and political impacts section. The results from these overlapping analyses will be combined in policy analysis.

C. Methods and Procedures

The availability of labor with the required skills to develop energy resources will be investigated both in an absolute sense and for the identification of labor shortages and bottlenecks. Basically, the input requirements will specify categories such as engineer (chemical, civil, mechanical), skill (welder, ironworker, carpenter), and function (production, supervisory), as well as separating development phases (construction, operation).

Personnel can either be recruited locally or imported. This difference, which is of importance in the analysis of socioeconomic impacts, can be addressed by examining current occupational and industrial patterns in the various areas, comparing them with projected needs, and projecting potential shortages of skilled personnel. Such shortages can be filled by training local people and/or recruiting from other regions.

Local recruiting is utilized most extensively when lease terms or other contractual obligations require it. This has occurred, for example, when energy companies have had to seek

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[2] University of Oklahoma, Science and Public Policy Program (1975) Energy Alternatives: A Comparative Analysis. Washington: Government Printing Office; and Radian Corporation (1975) A Western Regional Energy Development Study. Austin, Texas: Radian Corporation, 3 vols.

[3] Council on Environmental Quality (1975) MERES and the Evaluation of Energy Alternatives. Washington: Government Printing Office; and Carasso, M., J.M. Gallagher, K.J. Sharma, J.R. Gayle, and R. Barany (1975) The Energy Supply Planning Model. San Francisco: Bechtel Corporation, 2 vols.

mining leases for resources underlying Indian reservations. Although these negotiations cannot be accurately predicted; the political conditions at each of the scenario sites will be examined to estimate the likelihood of local-recruitment clauses.

Assuming that developers use extensive local recruitment, questions remain as to the productivity of recruited workers, and the costs of such programs. This can only be determined by experience. Therefore, experience on rapidly developed energy sites and their labor forces will be examined.[1]

Another local effect is a general inflation of wages. Likely wage scales will be compared with prevailing rates. If these diverge substantially, economic theory predicts a pattern of temporary and permanent wage and price impacts. These conclusions will be logically derived, then checked against the experience of previous boom towns.[2]

When considering inter-regional migration, a national perspective will be assumed. At this point the labor demands of

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[1] See for example, Burchival, Carrol. "Demonstration Program for Serving the Occupational Needs of Emerging and Expanding Business and Industry in North Dakota." On-going study sponsored by the Old West Regional Commission.

[2] Gilmore, J.S., and M.K. Duff (1974) A Growth Management Case Study: Sweetwater County, Wyoming. Denver: University of Denver Research Institute; and Institute for Social Science Research (1974) A Comparative Study of the Impact of Coal Development on the Way of Life of People in the Coal Areas of Eastern Montana and Northeastern Wyoming. Missoula, Mont.: University of Montana, Institute for Social Science Research.

all western energy projects will be aggregated and compared with national labor supplies for the various occupational groups. The availability of skilled workers willing to migrate to western energy sites will depend on a number of factors, for example: offered wages, wages in other employments, regional unemployment rates, workers' age distributions, educational attainment, and ethnic or cultural traditions.[1] A number of manpower forecasts will be evaluated critically and the results synthesized. In a less quantitative manner, the national communication channels by which jobs and workers are matched will be investigated primarily through industry and union publications and personal interviews.

Equally as important to the number of workers will be their demographic and social characteristics. The distinction between construction (essentially temporary) and operation personnel will be particularly crucial and an attempt will be made to determine whether these populations differ in any significant ways. There may, for example, be a class of workers who spend their careers in a series of temporary projects. Worker-profile studies have been done on both well-established and rapidly-expanded western energy

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[1] Pennsylvania State University, Institute for Research on Human Resources (1973) Demand and Supply of Manpower in the Bituminous Coal Industry for the Years 1985 and 2000. Springfield, Va.: National Technical Information Service.

projects.[1] By comparing and contrasting these, it may be possible to generalize about a community's development.

Obviously, unions may also play a critical role in facilitating the timely completion of projects. Although no formal tools exist for confidently predicting the course of bargaining situations, it will be important to determine whether no-strike agreements are likely on these projects (as has happened on the Alaskan pipeline, for example), how effective such agreements are, and how they will affect labor availability. The likely extent of unionization at these new projects, the relative shares represented by the unions involved, and contrasts with the unions' position in other mining areas will also be indicated when possible. Emerging patterns of "noneconomic" demands, for example, health and recreation services, may play an important role in shaping energy-impacted communities. If trends are noted in this area, they will provide useful information for socioeconomic impact analysis.

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[1] Steady-state communities: Leholm, Arlen, F. Larry Leistritz, and James Wieland (1975) Profile of North Dakota's Coal Mine and Electric Power Plant Operating Work Force, Agricultural Economics Report No. 100. Fargo, N.D.: North Dakota State University. Rapidly expanding communities: Chalmers, James, and Judith Glazner (1975) "Construction Worker Profile", study sponsored by Old West Regional Commission, performed at Mountain West Research, Inc.

D. Anticipated Results

Although there will be local hiring, it seems likely that few of the needed personnel will be recruited locally. In many of the scenario locations, there are simply not enough people in the area. Even if there were, however, many of the jobs will call for specific skills. This lends added importance to migration.

It is well-known that migrants tend to differ demographically from their sending populations as well as from their receiving populations: they are younger, more educated, and so forth.[1] In addition to these tendencies, the heavy construction industry exhibits certain other characteristics--most notably strong seasonal variations and hidden unemployment. Social Security statistics indicate that the number of individual workers employed in that industry during the course of a year can exceed the number on payrolls in an average week by a factor of two.[2] Heavy construction manpower demands are likely to be met in large part by persons seasonally unemployed from other industries. This implies a relatively elastic supply curve, but previous labor

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[1] Greenwood, Michael J. (1975) "Research on Internal Migration in the U.S.: A Survey." Journal of Economic Literature 13 (June): 397-433.

[2] Federal Energy Administration (1974) Project Independence Blueprint; Final Task Force Report: Labor. Washington: Government Printing Office.

market research will have to be examined more carefully to determine whether this is an accurate conclusion.

Preliminary examination of the industry suggests the existence of a group of construction workers who continually move about the country from job to job. If so, this would imply clear differences between the construction and operation phases in boom towns. For example, a lesser expenditure on housing has been noted in boom towns than compared to more-established towns of their size. This reflects (1) smaller families; and (2) greater use of mobile homes. (For example, 40 percent of the planned units in Colstrip, Montana are mobile homes.)[1]

E. Data Availability

Personnel requirements for many kinds of energy facilities (for example, electric power plants) are well established. Newer developments (for example, coal conversion), however, have not been deployed at full scale. Hence, all operating characteristics, including personnel requirements, are not now known and can only be estimated.

Substantial information is available on the numbers of people currently involved in all the various occupations. Moreover, the Bureau of Labor Statistics regularly publishes labor demand forecasts for selected skills. But this leaves open the question

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[1] See Myhra, David (1975) "Colstrip, Montana...the Modern Company Town." Coal Age 80 (May): 54-57.

of how many workers can be recruited from other jobs and other locations, and/or retrained.

The practices and effects of unions are difficult to measure meaningfully. Information in this area is fragmentary and usually not collected on a consistent basis. Nevertheless, certain basic factors, for example, proportions of workers covered by collective bargaining agreements by industry, are available.

F. Research Adequacy

Economic theory can be used to project qualitative features of the labor force, such as the relative extent of migration in various situations, demographic characteristics of migrants, and so on. Most research to date would have to be modified for this study to: (1) take into account the unique features of a large facility being placed in a sparsely populated area; and (2) detail migration histories, communication channels, etc., on an individual worker level.

The supply characteristics of occupational skills, although expected by theory to follow certain general patterns, have not been documented in any detail for the industries of greatest concern.

4.3.6 Financial Resource Availability

A. Introduction

Financial requirements related to energy development are important on two levels: the capital required by the energy industry for the development itself; and the financial requirements of local governments caused by the population influx. Both levels involve questions about the amount of capital required, the time frame over which it is needed, the sources from which it will come, and the institutions through which it will be channeled. All three concerns are being discussed extensively. The question of financial resource availability generally raises numerous issues that will receive attention in our policy analyses.

B. Baseline Data

Current patterns of financing the energy industry will be described. Basic data are available in compendia of the Census of Mineral Industries, Federal Power Commission, and the Bureau of Mines. The business press and trade publications will help to provide a more qualitative description of the institutions and procedures.[1] At the same time, these activities must be placed in the context of the capital markets. An overall picture will be derived from data in the Federal Reserve Bulletin, the

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[1] These may include, for example, Fortune, Coal Age, and Barron's.

Survey of Current Business, and studies produced by Chase Econometrics Associates.

Data on local government finances are available in the Census of Governments, state statistical abstracts, and special studies done as part of the environmental impact statement procedures. Tax rates and levels of service provisions are of particular concern. Information on the legal parameters of public finance policy (for example, constitutional restrictions on municipal debt), will be useful for policy analysis.

C. Methods and Procedures

Descriptions of the scenarios and ERDS include information on capital costs, detailed into types of equipment, on-site labor categories, and so forth. Furthermore, information is available on the time phasing of the developments. These data lead directly to estimates of required investment funds and carrying charges for each type of facility.

The impact on the national economy will extent far beyond the construction site. Each purchased piece of equipment results in an order to a manufacturer; that manufacturer places orders with other manufacturers, trucking companies, building contractors, etc. Input-output analysis[1] can be used to project the ultimate demand impacts of this process. The SEAS model uses an input-output

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[1]Yan, Chiu-shuang (1969) Introduction to Input-Output Economics. New York: Holt, Rinehart and Winston.

methodology in such a way that total capital investment can be projected, along with a lag structure describing the phased response to demands.

The total financial requirement (including manufacturing, transportation, and other subsidiary sectors), can then be projected for the nation as a whole. This will be compared with the overall capacity of the capital market and relevant components, for example, bonds, bank loans, leases. If western energy development is found to have a significant impact on these markets, indications of interest rate effects, diversion of capital from housing construction, and related impacts can be derived.

Whether or not energy development substantially impacts national markets, institutional innovation may be required.[1] Capital investment may far exceed the creditworthiness of the companies in the field, if present day procedures are applied. Such questions are inherently qualitative, so we will deal with them through a subjectively performed synthesis of informed opinion in the financial field.

Given current local tax rates, and anticipated population and economic changes (from our social, economic, and political impact analyses), the future growth of tax revenues can be charted. Furthermore, demographic variables can be used to

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[1]Wilson, Wallace W., interviewee (1975) "Project Financing, Customized Money Packages for Coal Mine Development". Coal Age 80 (April): 98-107.

indicate the need for expansion of governmental services. For example, given an estimate of school-age children, requirements for classrooms, teachers, buses, and other educational facilities can be derived.

Financial bottlenecks may develop in two areas: (1) the present value of revenues may fall short of the present value of required expenditures; or (2) expenditures may precede revenues thereby necessitating borrowing in one form or another. Each of these situations calls for its own set of responses; the former could be addressed through additional taxation, intergovernmental transfers of funds, territorial annexation, or retrenched service levels; on the other hand, the latter bottleneck would require selling bonds, providing for early payment of taxes, or using temporary facilities. These and other options will be addressed in the policy analysis phase.

D. Anticipated Results

There are differing views on the ability of the energy industry to finance new development through conventional capital markets.[1] The markets would seem large enough to handle investments of this

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[1] Hass, Jerome E., Edward J. Mitchell, and Bernell K. Stone (1974) <u>Financing the Energy Industry</u>. Cambridge, Mass.: Ballinger; and Lindauer, Robert L. (1975) "The Role of Market Capital in the Solution of Boomtown Problems". Paper presented at the Seminar on Financing Infrastructure in Energy Development Areas in the Western States, Snowbird, Utah, August.

magnitude without undue stress. However, risk elements may deter all but the most speculative investors. For example, some investors believe that current petroleum prices, now maintained by the Organization of Petroleum Exporting Countries, could fall, leaving alternative fuels producers without a market. Whether or not this reasoning is valid, if investors believe it, price supports, loan guarantees, or other governmental aid might be necessary to get them to participate.[1]

The extent to which western U.S. capital will be involved in energy financing is not known precisely, but it probably will be minimal. With less than four percent of the nation's population, the Rocky Mountain states could hardly be expected to contribute a major portion of the requisite capital. For the most part, financial matters will be dealt with by aggregating capital requirements over the region and comparing these figures with national (and international) markets.

On the local level, private capital will no doubt be redirected as new profit opportunities emerge. Savings and loan associations may liquidate (national market) bonds in order to finance a flood of new mortgages; local people will speculate in land; and so forth. These responses will depend critically on the financing decisions of government and the developers, so we

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[1] Oil and Gas Journal (1975) "Views Conflict on U.S. Oil-Shale Aid." 73 (October 13): 38.

will comment on them as an adjunct to the major financial questions.

In most of the scenarios, local and state revenues could grow enormously. This, combined with increasing returns because of increasing town size,[1] could insure the adequacy of local government resources <u>if</u> short-term cash flow needs are met. However, jurisdictional lines may sometimes complicate the situation. If a power plant is located in one county and the nearest substantial town in another county, the second county may bear substantial costs (for schools, for example) without being able to collect property taxes on the energy facility. On the other hand, the sales tax is probably more effective for the second county than for the first. While a state severance tax can be used as part of an equalization plan in this case, such an option would not be available if the jurisdictional line were a state border. Additional complexity and potential inequities may occur when facilities or towns are built on Indian reservations. These examples are only suggestive of the range of financial input issues with which the policy analysis must deal.

Even if over the long-run revenues will be greatly increased and taxes possibly reduced, communities will still usually have

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[1]Alonso, W. (1971) "The Economics of Urban Size". <u>Papers of the Regional Science Association</u> 26: 61-76.

a "lead time problem".[1] This is the problem of obtaining capital before revenues from development are available. For example, roads, sewers, schools and so forth must be built immediately, whereas the revenue to support them will flow in over a period of 20, 30, or more years; and local bonding capacity may be limited by state constitutions, investor formulae which are based on past revenues, or irreducible uncertainties about the future. Therefore, innovative approaches which have been proposed or which might be employed in attempting to resolve this problem will be described and analyzed.

E. Data Availability

Although extensive financial data are available, differences exist on their interpretation.[2] Generally speaking, there is greater public disclosure of governmental financial information than of corporate information, although investor concern has led to a consistent format and widespread dissemination of some corporate financial data.

Expenditures for personnel will be subject to considerable uncertainty until some of these new energy facilities have been

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[1] Lamont, W., and others (1974) Oil Shale: Tax Lead Time Study. Denver: Colorado Geological Survey.

[2] See, for example, the symposium entitled "Is There a Capital Shortage?" held at the convention of the American Economic Association, Dallas, Dec. 1975.

constructed. Financial needs of local governments can be projected somewhat more accurately if good information on future population expansion and local taxation procedures and rates can be obtained.

F. Research Adequacy

The Census of Governments has taken steps toward compiling standardized information on local finances, but it is far from complete. In doing an adequate local impact analysis, information would be needed on specific tax rates, fiscal authority of local agencies, constitutional restraints on borrowing, and so on. As noted, a considerable research effort would be needed to collect and standardize this information.

On the national level, financial markets are complex and not well understood, due mainly to the interdependencies between financial sub-sectors. Economists can only indicate in rough terms the likely sources of capital for proposed large-scale energy development. Mechanisms actually being used by energy companies today can be documented with somewhat greater assurance. It is not clear whether current methods can be scaled up without extensive mergers, innovations, or government support.

A fundamental question concerns the appropriate interest rate to be used in discounting future costs and benefits. An extensive literature has grown in response to this problem, but agreement is not yet universal. It may still be necessary to do a parametric analysis using a range of interest rate assumptions.

4.4 ECOLOGICAL IMPACTS

4.4.1 Introduction

The ecological impacts analysis examines changes (arising from energy development scenarios) primarily in terms of alterations in biotic systems.[1] This analysis examines the composite effects on existing ecosystems[2] of physical impacts previously discussed under transport modeling, changes in land use and quality and availability of water resources, and parts of the social, economic, and political analysis described in the following sections.

A number of ecological impacts have been identified as significant issues and will receive particular attention. These will include a variety of potential changes to terrestrial and aquatic communities. For example, surface mined land reclamation, especially in more arid areas, and shale spoil revegetation have already raised important issues. The magnitude of other issues is more difficult to assess, such as the introduction of new recreational activities and land uses, and potential changes to

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[1]Effects on human health are described in Section 4.6

[2]An ecosystem can be defined as a functionally interacting biological community and physical components that occur in a given area.

vegetation from acid rain. Significant changes to aquatic communities may stem from a number of energy related activities, such as alterations in stream flow or water quality. In addition to identified potential impacts such as these, this analysis is intended to identify other biological impacts that might raise significant public policy issues.

Analytical goals for ecological impacts analysis include:

1. providing a general baseline description of the existing conditions and trends in the ecosystems studied;

2. evaluating the nature and extent of alterations to this baseline related to the residuals from energy development: land and water use; air and water quality changes; and population growth;

3. within the priority framework described in this section, evaluating the combined impacts of development residuals and other simultaneous stresses on the ecosystems, using selected ecosystem parameters and significant species;

4. assessing the limitations of existing data and ecological knowledge for identifying, solving or mitigating these problems, and indicating priorities in needed research.

A number of boundaries have been established for the analysis of ecological impacts, both in terms of geographic scope and level of detail. Geographic boundaries are largely determined by the extent to which significant impacts can be felt. Boundaries of the ecological studies of scenarios may, therefore, differ from those used in other portions of this study.

During the first year, the main focus will be on changes at the level of the ecosystem and to significant ecosystem components. Within this perspective, emphasis will be placed on the ecology and habitat requirements of identified "major species". These major species will be selected on the basis of their ecological importance or sensitivity to anticipated impacts. All major species will, therefore, be indicators of ecological stability, in that changes in their populations would either affect the stability of the ecosystem directly or signal the attainment of levels of disturbance which could be potentially important in ecosystem terms. In addition, attention will be given to species of interest to humans, such as game animals and fish or endangered species, since existing management systems are largely oriented around them. In this way, the study may be kept close to relevant policy issues and the available means of approaching ecological problems.

Impacts brought about by changes in land and water use will receive special emphasis. This task is viewed primarily as a review of existing data and a synthesis of pertinent information. The level of detail, for example, will not approach that of a typical environmental impact statement.

The organization and sequence of this analysis, described in subsequent sections, is shown in Figure 4-2.

Baseline Data Collection	Initial Ecological Impact Analysis	Higher Order Ecological Impacts
Geographic distribution of basic ecosystem units	Evalute the extent of direct habitat loss and changes in primary production resulting from land use residuals	Estimate and map the extent of terrestrial communities which will be affected indirectly by population growth
Tabulate ecosystem unit gross and net primary productivity	Evaluate impact on aquatic communities of the development of regional water supplies, and wastewater discharges	Analyze and discuss the susceptibility to extinction of endangered species with respect to cumulative reduction or alteration in aquatic and terrestrial habitat
Identify a group of "major species" for specific attention and locate areas of critical habitat	Evalute extent of other modifications in habitat, as by mine spoil reclamation	Identify cumulative impacts on sports fisheries and wildlife of habitat loss, increased human populations, and changes in land use patterns
Provide qualitative description of interrelationships between the selected animal species and vegetation types, and seasonal changes	Identify impact of hazardous substances introduced into the biotic environment as air and water residuals	Potential for habitat succession and recovery
Identify major existing stresses on these species, and current population trends		

Figure 4-2: Major Elements in Ecological Impact Analysis

4.4.2 Baseline Data

Baseline data will be required to provide adequate background descriptions of conditions and trends in existing ecosystems for the assessment of the impacts of energy development. This background description relies primarily on existing data availability identified and described in Section 4.4.5. The methodology for developing this data base will be systematically to review, tabulate, and describe the parameters identified below:

1. the distribution of major vegetational units. (Vegetation units and their associated fauna are subsequently termed "ecosystem units.");

2. quantitative estimates, at the local scenario level, of annual gross primary production[1] (for indicating total community energy flow) of each major vegetation unit, with estimates of seasonal variation, where possible. In addition, data on energy available to animals (net primary production) may also be tabulated;

3. lists of dominant animal species characterizing the major vegetation types;

4. description of the habitat requirements of selected game species, endangered species, or other species of immediate ecological or human interest ("major species") found in each ecosystem unit; and

5. recent trends in habitat quality and population size and condition of major species.

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[1]Gross primary production is a measure of the total photosynthetic potential of vegetation, net primary production is a measure of this potential minus energy used in plant respiration.

Much of the baseline ecosystem data will be summarized as maps of major ecosystem units (see Figure 4-3, for example), as well as of critical habitat for major species, at both the local and regional level (see Figure 4-4). In addition, brief qualitative descriptions of plant and animal assemblages typical of each ecosystem type will be prepared, along with tabular descriptions of the major aspects of the ecology of the individual major species, including such factors as food habits, preferred cover types, seasonal changes, and the environmental factors that currently limit population size. Table 4-7 provides an example. Baseline data will be limited to those needed to support analyses described in the following sections.

4.4.3 Methods and Procedures

The initial assessment of ecological impacts will use the descriptions of residuals and their physical impacts to evalute changes in ecosystem productivity and diversity due to changes in land use, and to discuss the exposure of major species to hazardous quantities of water and air pollutants. The goal is to describe changes in existing conditions which contribute to the more complex impacts assessed in the subsequent section. The parameters to be addressed in this section include: (1) change in the areal extent of existing ecosystem units and importance of habitat loss to affected wildlife; (2) change in primary production;

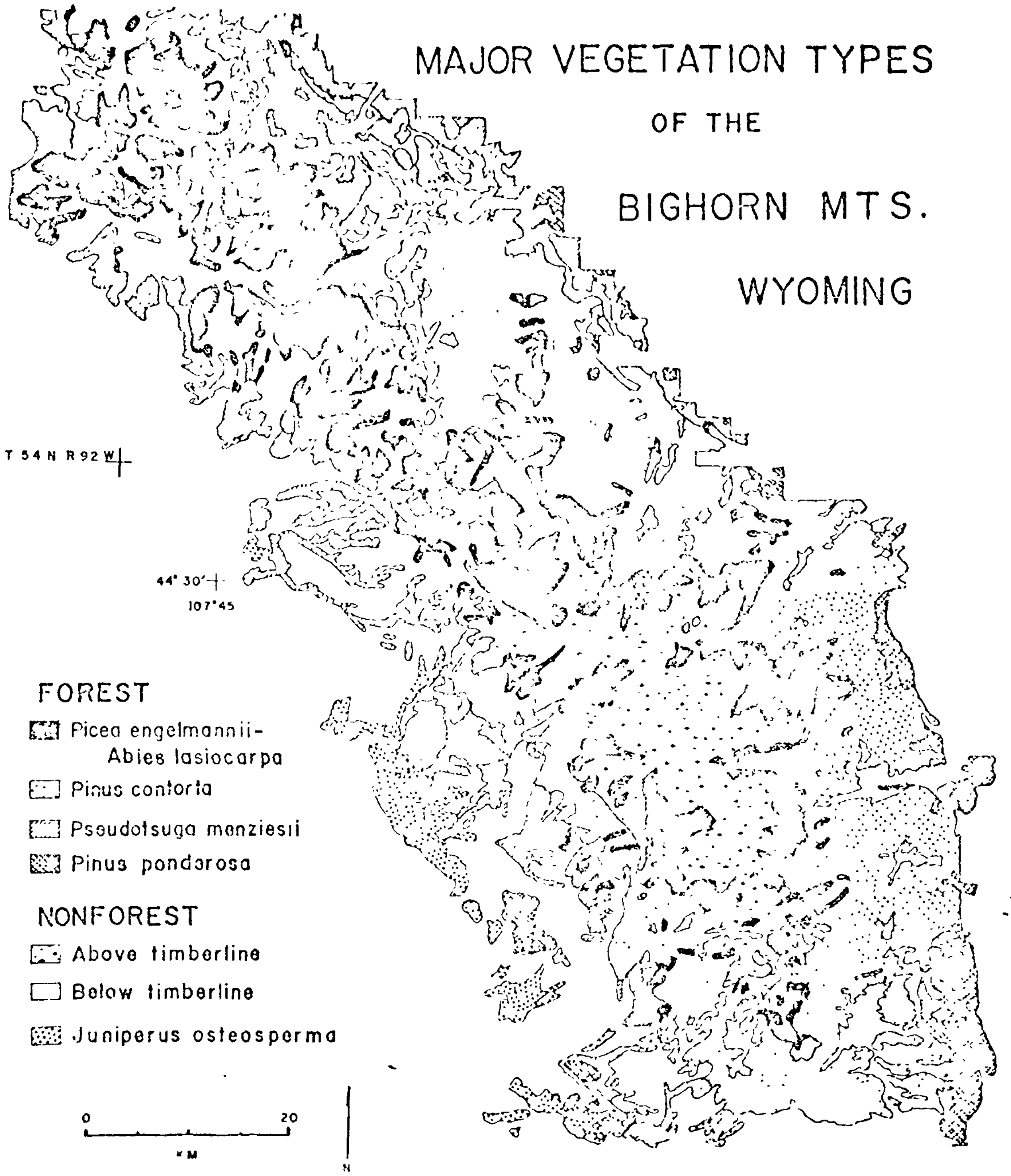
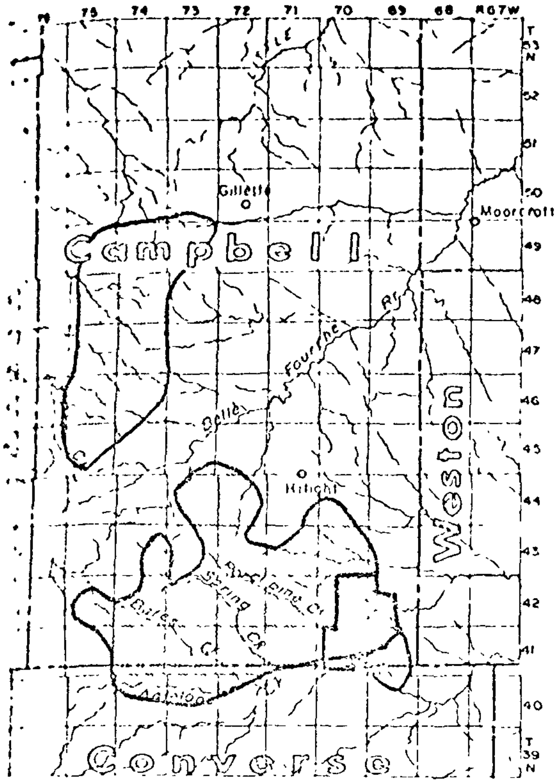
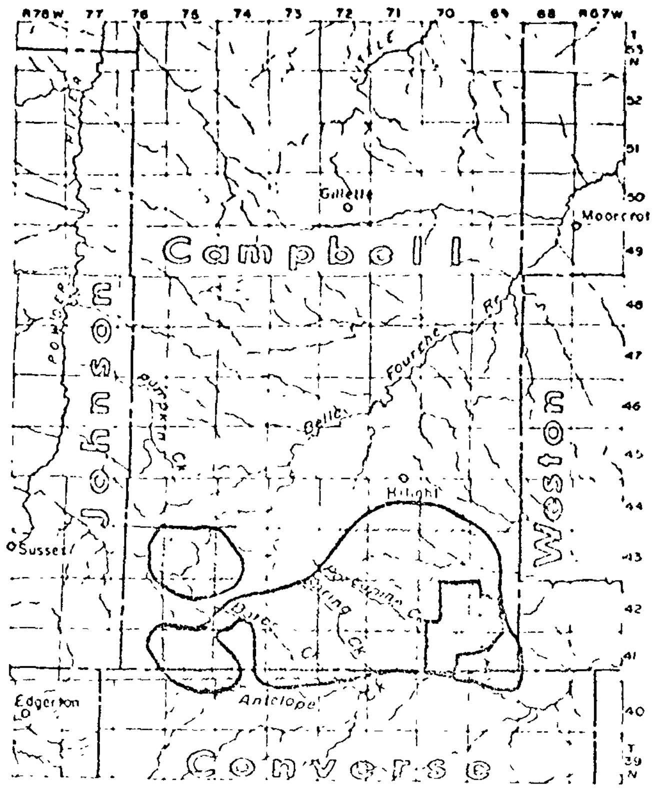


FIGURE 4-3: EXAMPLE OF VEGETATION MAPPING AT A REGIONAL SCALE

Source: Despain, D.G. (1973) "Vegetation of the Big Horn Mountains, Wyoming, in Relation to Substrate and Climate." <u>Ecological Monographs</u> 43 (Summer).



Winter antelope concentration areas (shaded) for the southern portion of the Gillette Antelope Management Area (1955-1956)



Winter antelope concentration areas (shaded) for the southern portion of the Gillette Antelope Management Area (April, 1959)

Figure 4-4: Example of Critical Habitat Map for Major Species, Local Scale

Source: Wyoming Coal Gas Company and Rochelle Coal Company (1974) Applicant's Environmental Assessment for a Coal Gasification Project in Campbell and Converse Counties, Wyoming.

TABLE 4-7: SELECTED MAJOR SPECIES OF THE FARMINGTON AREA

Species	Residency Status	Vegetation Zone	Habitat Preferences	Food Preferences	Nest or Den	Major Stresses	Population Status
Mule deer	Year long	Pinyon-Juniper mountain brush (semidesert shrub)		Browse, some forbs		Habitat quality and weather	Declining
Antelope	Year long	Grasslands (semidesert shrub)	Open country	Grasses and forbs		Competition from livestock; water	Declining
Wild turkey	Year long	Ponderosa pine-Douglas fir	Open pine stands with abundant edge	Pine seeds, berries, grasses, grasshoppers	Edges of deciduous trees and brush	Timbering, winter weather	Declining
Waterfowl	Migratory, some breeding	Riparian and lakeshore marsh (ponds)	Irrigated lands interspersed with native vegetation	Grain, seeds, grass, aquatic plants, snails, and crustaceans	Ground within a mile or so of water; ponds and stock tanks		Stable
Cottontail	Year long	Riparian and floodplain; semidesert shrub and grassland	Riparian lands; washes with brushy cover	Vegetation of various kinds	On ground		
Marsh hawk	Resident	Riparian and grassland	Hunts in open country	Small mammals, birds	Ground in marsh or grasslands		
Gray fox	Year long	Widespread	Brush, lowlands (nocturnal)	Rodents, rabbits, reptiles, berries, fruit	Burrow, den or hollow log		
Coyote	Year long	Widespread	Open spaces	Small mammals, fruits and berries	Burrow or hollow log	Human control measures	Stable
Black-footed ferret	Possible resident	Semidesert shrub and grassland	Mesa tops (?) (nocturnal)	Prairie dog	In dog town	Limited food supply	Rare
Peregrine falcon	Possible resident or migrant	Riparian or near water	Cliffs	Medium-sized birds	On ledge	Shooting, probably pesticides	Rare
Spotted bat	Possible resident	Semidesert shrub; riparian vegetation	Rocks, caves, cliffs	Insects			Rare
Prairie falcon	Possible resident	Semidesert shrub and grassland, sandy areas	Rough country	Birds, mammals, grasshoppers, crickets	On ledge	Shooting, probably pesticides	Rare
Burrowing owl	Resident	Semidesert shrub and grasslands, sandy areas	Near prairie dog towns	Insects, small vertebrates	Burrow in ground, sometimes an old rodent hole	Decline of prairie dog	Rare

and (3) qualitative description of the significance of hazardous emissions and effluents to ecosystems. This information is pertinent to a variety of policy areas, such as establishing protective measures for limiting toxic wastes, developing ecologically oriented siting requirements, and providing a framework for ecologically reasonable reclamation requirements.

A. Methods of Initial Impact Analysis

The evaluation in this section will be made primarily by superimposing the activities described in each scenario on existing ecosystem patterns. Methods appropriate to the selected parameters are described below.

1. Changes to Areal Extent of Ecosystem Type: Siting areas within which scenario components are envisioned will be mapped, and these maps compared with the distribution of ecosystem types and key wildlife and aquatic habitat developed in the baseline section. This will allow the "significance" of the habitat available within these siting areas to be compared with remaining untouched habitat as a means of setting an initial value in the kinds of lands which could be removed from productivity.

   Then, the total quantities of land required by the scenario components can be used to determine the significance, with respect to remaining habitant, of removing known quantities of certain ecosystem types.

2. Changes in Gross and Net Primary Production: Productivity estimates from the literature (as a part of the baseline descriptions), will be applied to the extent of habitat to calculate existing and changed levels of production within a local scenario site. This method has been used by H.T. Odum for a

number of assessments of the impact of proposed developments.[1]

3. Qualitative Assessment of the Significance of Alteration: This analysis will review available literature and describe in summary form the major changes in the overall quality of habitat resulting from direct scenario land-use impacts. These summary descriptions will parallel descriptive approaches used in environmental impact statements (see section on information sources). Several major points likely to be addressed include: (a) effects on terrestrial and aquatic habitat due to construction and operation of water supply systems; and (b) relationship of the success of reclamation efforts to the use and quality of surrounding habitat.

4. Qualitative Assessment of Hazards Posed by Air and Water Residuals, and Settling Ponds: This portion of the analysis will review available literature and identify factors which may act as stresses or hazards to major species or significant ecosystem processes. Major points to be addressed are: (a) potential for damage to vegetation due to acid rainfall; (b) characteristics of surface waste impoundments, such as size and presence of toxic substances, and likelihood of their use by different kinds of wildlife.

B. Methods of Analysis of Higher Order Impacts

This analysis of higher order impacts will focus on such factors as the effects of changes in water quality and quantity stemming from regionwide water resource development on aquatic ecosystems. Emphasis will be placed on the cumulative impacts

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[1] Odum, H.T., C. Littlejohn, and W.C. Huber (1972) An Environmental Evaluation of the Gordon River Area of Naples, Florida and the Impact of Developmental Plans. Gainesville, Fla.: University of Florida, Department of Environmental Engineering Sciences.

of industrial, agricultural, and municipal/domestic activities. Another major focus will be the indirect effects of increased human populations on ecosystem units short of actual modification or removal of habitat. This will provide information on the cumulative effect on major species of the combination of direct habitat loss and modification of remaining habitat. The analysis in this section will provide information relevant to such policy questions as the need for additional wildlife refuge lands, land-use planning, water allocations, protection of wildlife species and funding priorities for research. This higher order analysis will be primarily descriptive, but several methods will be applied to describe systematically the complex effects to be assessed. Three techniques will be employed: (1) interaction models to trace the interrelationships of the major primary impacts on the whole ecosystem; (2) network analysis to identify the higher order consequences of development; and (3) cross-impact accounting matrices to check for potential omission of significant consequences.

1. Interaction Models: The interaction models are systematic diagrams that posit a given change in baseline conditions and display the range of initial consequences that are likely to stem from it. Although they are somewhat subject to the influence of the background and knowledge of the investigator, they do provide a summary of the major interactions between aspects of any energy development and the surrounding environment as depicted in Figure 4-5.

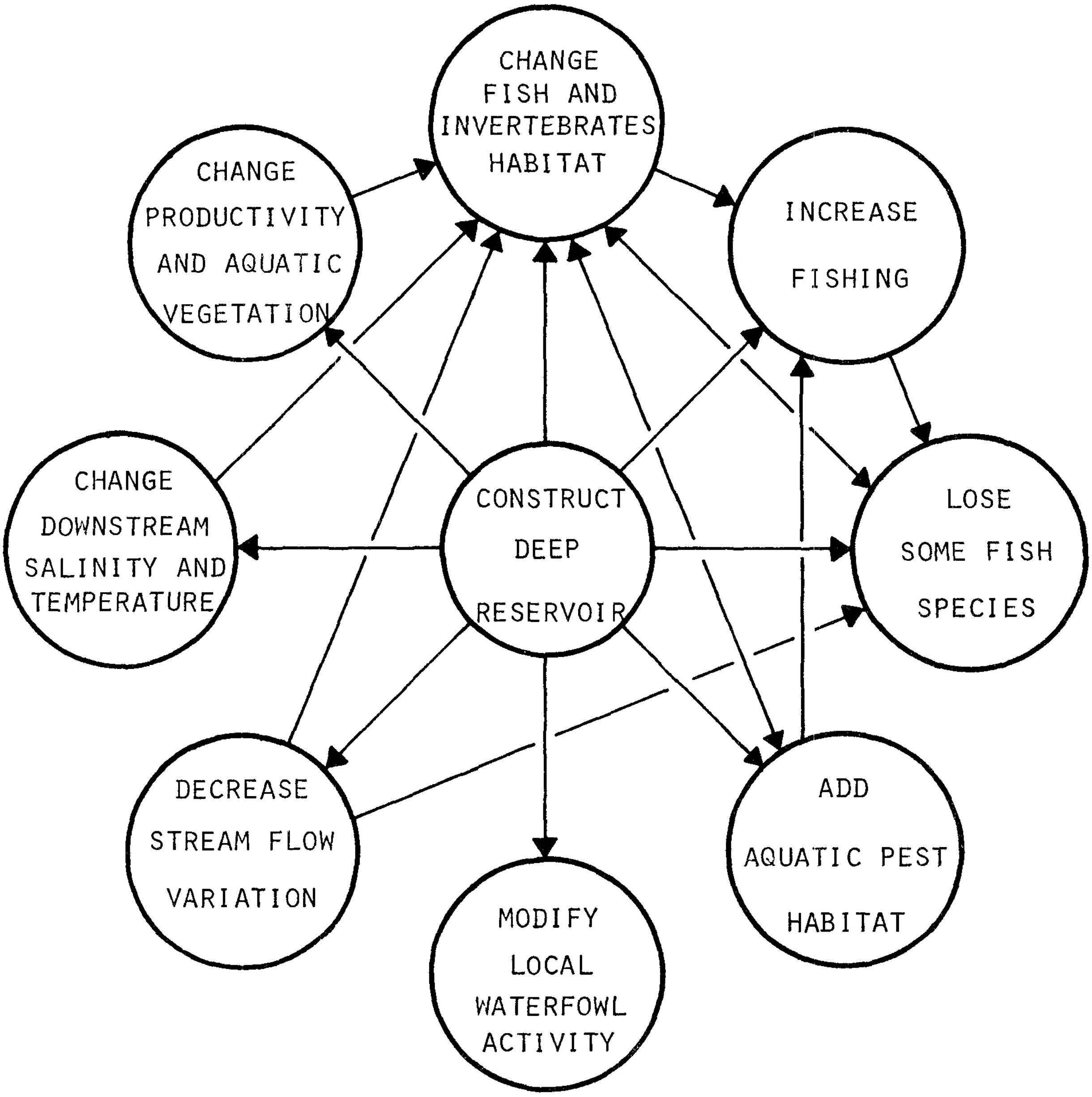

Figure 4-5: Simplified Interaction Model Diagram

2. Network Analysis: By this technique, the local impact of a given residual is traced outward schematically through a series of first-, second-, and higher-order consequences (see Figure 4-6). While this approach ordinarily results in a diagram too complex for use in presenting results, it allows the various interactions in a complex system to be accounted for, so that important higher-order effects are not overlooked.

3. Cross Impact Matrices: This method incorporates a list of anticipated changes in existing baseline conditions in addition to a checklist of potentially affected ecosystem functions and components. These two lists are related in a matrix which identifies cause/effect relationships between specific activities and impacts.[1] In this study, the matrix will be used to provide a check on the completeness of identified impacts, rather than to analyze or quantify changes in the ecosystem.

4.4.4 Anticipated Results

Anticipated results and their form of presentation will include: (1) maps of areas where ecosystem degradation by increased human populations is considered likely, and discussion of the significance of this effect; (2) discussions of the relative susceptibility of major species to population decline due to alteration in habitat availability; and (3) discussion of the nature of impacts on the aquatic environment associated with regionwide water use. These anticipated results will be discussed

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[1] Leopold, Luna B., Frank E. Clarke, Bruce B. Hanshaw, and James R. Balsley (1971) A Procedure for Evaluating Environmental Impact, Geological Survey Circular 645. Washington: Government Printing Office.

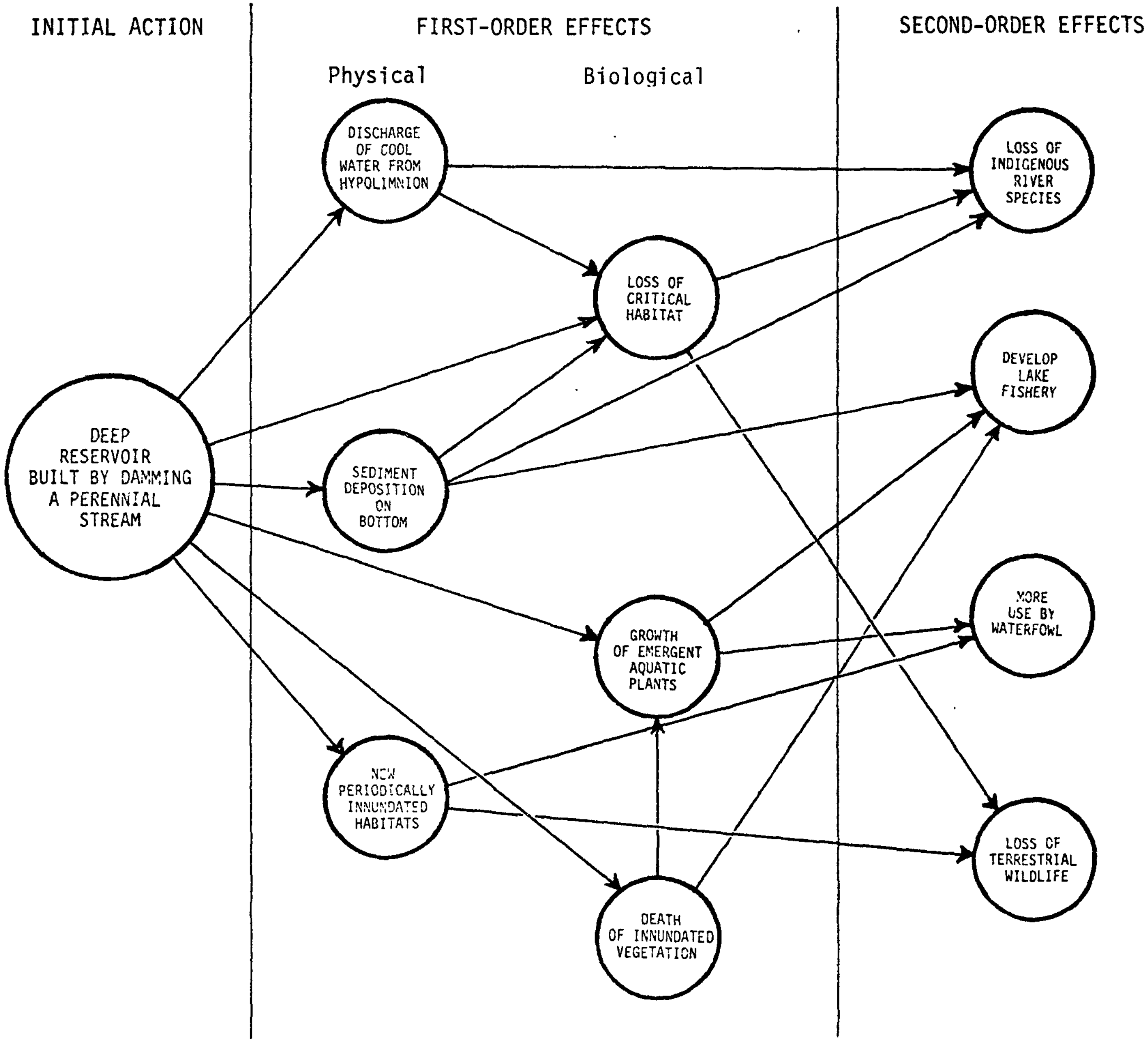

Figure: 4-6: Simplified Network Analysis in terms of their potential irreversibility, temporal, and geographic extent, and the possibilities for mitigation.

4.4.5 Data Availability

A number of data sources will be used as input for the analysis of ecological impacts. These data sources include literature searches using on-line data bases such as Biological Abstracts, Toxline, various government publications, personal contacts, and surveys of agencies, universities and other national and regional research and information centers. Major sources of information for this section of the assessment include federal level planning documents,[1] environmental impact statements,[2]

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[1]Department of Agriculture, Forest Service (1974) Prescott National Forest Multiple Use Guide; Department of the Interior, Bureau of Land Management (1973) Unit Resource Analysis Report of Virgin Valley Planning Unit, Cedar City District, Utah; Department of the Interior, Bureau of Land Management (n.d.) Management Framework Plan for the Vermillion Planning Unit, Kanab District, Utah; Missouri River Basin Interagency Committee (1971) Comprehensive Framework Study, Missouri River Basin; and Upper Colorado Region State-Federal Interagency Group (1971) Upper Colorado Region, Comprehensive Framework Study.

[2]Colorado-Ute Electric Association, Inc. (1974) Applicant's Environmental Assessment, Yampa Project, Craig, Colorado; Department of the Interior (1973) Final Environmental Statement for the Prototype Oil Shale Leasing Program. Washington: Government Printing Office, 6 vols.; Department of the Interior, Bureau of Land Management (1975) Draft Environmental Impact Statement, Kaiparowits Project; Department of the Interior, Bureau of Reclamation (1974) Draft Environmental Statement, WESCO Coal Gasification Project and Expansion of Navajo Mine by Utah International, Inc., New Mexico; Department of the Interior, Bureau of Reclamation, Upper Colorado Region (1974) El Paso Coal Gasification Project, New Mexico, Draft Environmental Statement; and Wyoming Coal Gas Company and Rochelle Coal Company (1974) Applicant's Environmental Assessment for a Proposed Coal Gasification Project in Campbell and Converse Counties, Wyoming.

game range maps, habitat utilization studies and similar documents[1] and scientific literature and personal interviews with government and academic researchers active in the geographic areas of interest.

Although large quantities of detailed information are available from the above sources on specific locations and species, studies are of inconsistent quality and do not cover the entire area of interest to this project. The structure of ecosystems is poorly understood in many parts of the West and research presently being conducted at that level is not applicable to all of the scenario areas. Quantitative data on population sizes and primary ecosystem parameters such as productivity or carrying capacity for a given species are sometimes available, but are of inconsistent quality and incomplete over the western region.

Ecological baseline data are generally limited for most Indian reservations. Mapping and discussion of trends in wildlife and fisheries are particularly important for the Crow and Northern Cheyenne reservations in the Colstrip area, for the Southern Ute, the Ute mountain, and the Navajo reservations (Kaiparowits/Escalante and Navajo/Farmington), and the Fort Berthold reservation in North Dakota.

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[1] Knapp, Stephen J. (1975) Birney-Decker Wildlife Study. Helena, Mont.: Montana Department of Fish and Game; Martin, Peter R. (1975) Sarpy Basin Wildlife Ecology Study. Helena, Mont.: Montana Department of Fish and Game; and Mussehl, T.W., and F.W. Howell (1971) Game Management in Montana. Helena, Mont.: Montana Fish and Game Department.

The acid rain question will have to be treated by comparison to existing situations, where acidity of rain has been related circumstantially to air pollution. Impact projections in this area will accordingly be of low accuracy.

The behavioral response of wildlife to impounded wastewaters cannot be predicted in any theoretical sense. Assessment of this hazard will be based on the known behavior of species with respect to similar bodies of water, the degree of comparability remaining a matter of informed conjecture. The amount of relevant information available about wildlife behavior is very scanty, and is not easily comparable to the conditions under study.

Data on regionwide water demands will be subject to constraints discussed in Section 4.3.1. Effects of consumptive use on TDS can be modeled, but effects on temperature will have to be inferred, as they will vary considerably on a local scale.

Few hard data on the response of regionwide populations to habitat loss and attrition are available. Conclusions will have to be drawn on the basis of inference and informed judgment. Limited comparisons with prior experience in areas with growing human populations can be made. Modeling is limited by the unavailability of reliable input data, and the many uncertain behavioral parameters involved.

4.4.6 Research Adequacy

A variety of gaps in ecological data and analytical models currently exist that limit accurate prediction of the ecological impacts that are addressed in this study. These limitations include both baseline data on the composition of ecosystems, and the response of these systems to changed conditions. A number of the research needs presently identified as useful to this TA include:

1. case studies of wildlife response to habitat loss;
2. studies relating primary productivity to natural climatic variability and species ecotypes;
3. further observations on the long-term success of mine spoil reclamation in various climatic regimes;
4. case histories and direct observation of the effects of increased human populations and recreational pressures on resident wildlife of previously undisturbed areas;
5. range size, limiting factors and habitat needs of major game and endangered species at a local level. Need to document regional differences;
6. ecological relations and sensitivity to pollution or disturbance of species important to the stability of the ecosystem, such as pollinating insects;
7. vegetation mapping at the level of detail of Küchler[1] for the state of Kansas needs to be carried out for all states;

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[1] Küchler, A.W. (1973) "Problems in Classifying and Mapping Vegetation for Ecological Regionalization." Ecology 54 (Late Spring): 512-523.

8. land-use maps of the type presently being made from satellite photographs by National Aeronautics and Space Administration (NASA) need to be developed for the western states, as is presently being done by the U.S. Geological Survey; and

9. projections of the growth of agriculture, and associated land use, need to be made for the time period of this study.

4.5 SOCIAL, ECONOMIC, AND POLITICAL IMPACTS

4.5.1 Introduction

When energy development occurs in an area, socioeconomic impacts arise from two principal sources. One of these is the change in population, initially during construction and later when the plant or facility is placed in operation. The other is the change in the local economy due to salaries, tax revenues, and plant expenditures.[1] Both of these impacts generate other changes and impacts in the community and in the region, especially on the community needs and services, culture and governments of the area. For example, a population influx increases the need for housing, utilities, schools, roads, and health care which frequently cannot be met by existing community services. Local governments often cannot meet these needs through taxation because tax-producing developments are usually located in the county, whereas people tend to live in the communities nearby which may not share in increases to their tax base.[2] Also, antagonisms may

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[1] Consequences, attributable to energy development at a particular location, could be traced back to areas that are far removed from the location. In this study, socioeconomic impact analysis will be limited to the locations and areas specified in the site-specific and aggregated scenarios.

arise between newcomers to the area and long-time residents, leading to social and political conflicts. Impacts such as these are explored and assessed in this impact analysis.

The purpose of this analysis is to examine and assess the impacts of energy development on several aspects of social, economic, and institutional structure for each scenario area. These impacts are likely to result in both benefits and costs for individuals, for social groups, for entire communities, and for the various institutions and levels of government.[1] A number of possible policy alternatives can be considered to alleviate or mitigate the issues which arise as a result of these problems. Assessing the ways in which policies may affect these problems provides a means of evaluating these policy alternatives. For example, the construction of new towns in energy development areas allows many potential impacts to be largely localized, whereby impacts on existing communities are lessened by the provision of certain services, such as housing and shopping, in the new town. If a new town is not built, other localities may sustain even greater impacts.

A simplified view of the categories we are using to trace the effects of energy development on a local area is presented

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[2] R. L. Lindauer (1975) "Solutions to the Economic Impacts of Large Mineral Development on Local Government", in Federation of Rocky Mountain States, Energy Development in the Rocky Mountain Region: Goals and Concerns (Denver: Federation of Rocky Mountain States), pp. 63-68.

[1] It should be remembered that this technology assessment is a research effort based on secondary sources, which largely precludes the possibility of gathering original data, including attitudes of residents and local authorities. There is, then, a heavy reliance on completed and ongoing studies in the western states.

in Figure 4-7. This graphically illustrates the assumption that changes in population and in the local economy are the immediate results of energy development. This assumption is employed in this impact analysis to simplify the sequence of analyses; clearly, interconnections and feedbacks other than those illustrated exist.

Data for sets of variables considered important will provide a basis for assessing the impacts of energy resource development on some critical social, economic, and political facets of life and, as discussed below, will be evaluated for each scenario.[1]

4.5.2 Baseline Data

Statistical data and the findings of other studies form the set of baseline conditions for the scenarios. The year 1975 is employed as the base year. However, in some locations these baseline conditions are somewhat dependent upon the extent to which energy development has already taken place. Impacts due to energy resource development on population, services, housing, and economic structure at locations, or in areas, where energy development has already begun will be difficult to isolate. In

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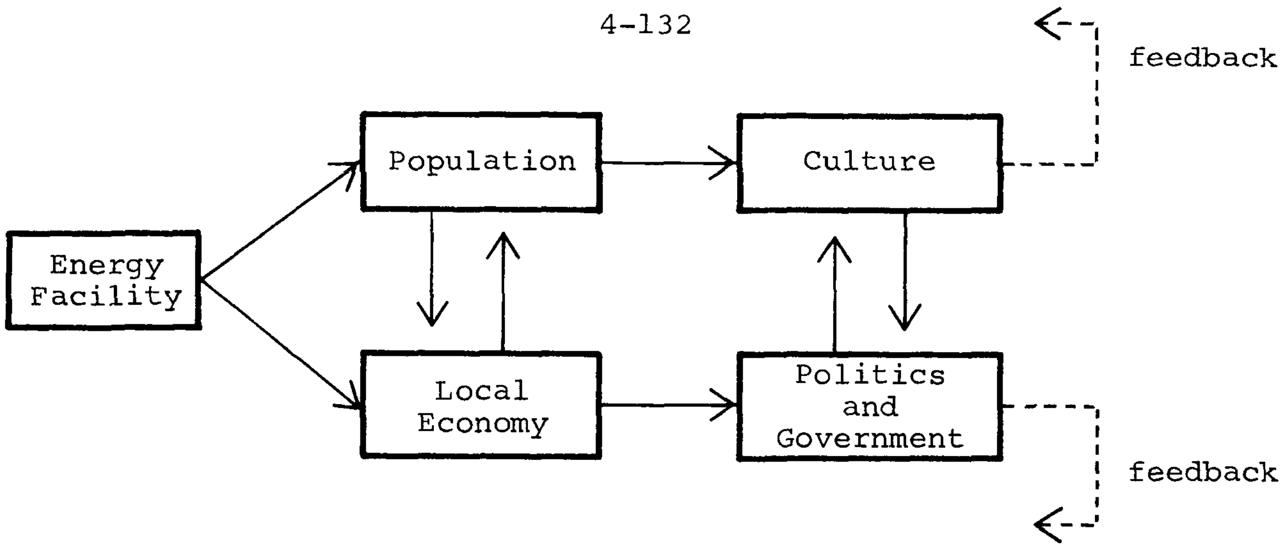
[1]The "boom" side of energy development will be emphasized during the first and second years of the assessment, consistent with the year 2000 time frame; most energy facilities have an expected life of about 30 years. In the second and third year assessments, increased attention will be given to the post-development termination phase or "bust" effects on communities.



Population:

Number and distribution (age, sex, ethnicity, location)
Housing (type, value, quality, number)
Characteristics (income, education, unemployment, occupations, and skill levels)

Local Economy:

Sectors and employers
Related industries
Commuting patterns
Transportation services
Private services

Culture:

Quality of life
Sense of community, life-style

Politics and Government:

Laws and planning capacity
Politics and interest groups
Revenues
Public services

Figure 4-7: Categories of Analysis in Assessing Effects of a New Energy Facility on a Local Area some cases, baseline social, economic, and political data may include changes that have occurred as a result of energy resource development prior to 1975. As a practical matter this is difficult to avoid. For example, development of energy resources at Gillette, Wyoming, began prior to 1970 and the 1970 census data reflect impacts from this.

4.5.3 Methods and Procedures

As explained in Chapter 3, two different means are used for measuring changes which occur due to the energy developments described in our scenarios. Site-specific and aggregated scenarios, except for the eight-state regional scenario, specify a level of energy development, the impacts of which can be compared to conditions existing in our baseline year, 1975. The regional scenario specifies and compares impacts from both high and low levels of energy development. Projected developments specified in all scenarios cover three time periods: the present to 1980; 1990; and 2000. Projection and discussion of social, economic, and political conditions during all three time periods will be made for each of the variables and subject areas considered, generally on the basis of counties and subcounty areas.

A. Population Impact

Projections of population conditions will be based on probable construction and operation phase employment.[1] The two phases produce different impacts, both in terms of population and other higher-order effects. The difference between the phases and their impacts will be emphasized, such as the different employment-population effects associated with the phases.

For areas where significant changes in population and economy have already occurred and will continue, the economic base model provides an estimate of the service-related population needed to complement a known population of basic (or export) workers[2] and

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[1]Commonly used population projection methods, which are based on migration responses to employment and unemployment, are rather unrealistic for energy development areas. In the energy development case, immigrants do not respond mechanistically to long-term, measurable trends in income or unemployment, but move to new job opportunities created by the construction and operation of energy-related facilities. These short-term causes generally are not measurable in existing population and migration models (see, for example, Greenwood, M. J.[1975] "Research on Internal Migration in the United States: A Survey." Journal of Economic Literature, 13 [June], pp. 397-433). The Utah Process model attempts to include the short-term factors, based on spatial aggregates of several counties, and analyzing the effects of several economic developments together. The fact that these regions and sets of events (alternative futures) cannot be separated renders this otherwise excellent model unsuitable for this study. See Weaver, Rodger, Ross Reeve, Dwight Ellingwood, Bruce Stowell, Robert Catlin, and Anna Williams (1975) The Utah Process: Alternative Futures, 1975-1990. Salt Lake City: Utah Office of the State Planning Coordinator. A refinement of the Utah model for the Navajo reservation may be more useful to the TA when it is available.

[2]Basic (export) workers manufacture goods that are exported from the local area.

their families.[1] The economic base multiplier is a quantification of this employment-population relationship. Projections of such employment and population for both construction and operation phases of energy facilities are also highly dependent upon the timing and sequencing of construction, particularly for scenarios where more than one energy facility is postulated. This aspect of the socioeconomic analysis will utilize the most accurate available information about planned developments, as well as reasonable information for hypothetical developments in the scenarios. Clearly, the assumptions employed in the projections of multiple facilities will influence the results. Information concerning occupation, education, and skill types of energy workers will be included in these projections, as will the demographic composition of the population. The geographical distribution of the population for the three time periods will be projected, since different population concentrations will have different impacts.

A number of impacts occur directly as a consequence of population change. A major area of impact is the stress placed on housing, public services (such as schools, health facilities, and roads), and private services (such as utilities and retail shops). Clearly, demand for these causes both the local economy and local government to attempt to provide them.

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[1] P. E. Polzin (1973) "Urban Employment Models: Estimation and Interpretation." Land Economics 49 (May): 226-233.

To a large extent, these service needs are closely related to population changes so that projections of service impacts will be made from population projections.[1] Housing and educational needs, for example, will be projected largely by employing assumptions about the demographic structure of the area, in terms of number of families and number of school age children. (If local data are not available, national or state structures will have to be used.)

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[1]A variety of previously conducted local studies will be employed to provide comparisons of projections, error ranges, and assumptions (Dalsted, Norman L., F. Larry Leistritz, Thor Hertsgaard, Ronald G. Frasse, Richard Anderson [1974] Economic Impact of Alternative Energy Development Patterns in North Dakota, Final Report prepared for the Northern Great Plains Resources Program. Fargo, N.D.: North Dakota State University, Department of Agricultural Economics; Dickenson, D., L. Johansen, and R. D. Lee [1975] Energy-Rich Utah: Natural Resources and Proposed Developments. Salt Lake City: Utah Department of Community Affairs; Federation of Rocky Mountain States [1975] Energy Development in the Rocky Mountain Region: Goals and Concerns. Denver: Federation of Rocky Mountain States; Gilmore, J. S., and M. K. Duff [1974] A Growth Management Case Study: Sweetwater County, Wyoming. Denver: University of Denver Research Institute; VTN Colorado [1974] Socioeconomic and Environmental Land Use Survey for Moffat and Rio Blanco Counties, Colorado, Summary Report prepared for W. R. Grace and Company. Denver: VTN Colorado; and Westinghouse Electric Corporation, Environmental Systems [1973] Colstrip Generation and Transmission Project: Applicant's Environmental Analysis. Pittsburgh: Westinghouse). Theoretical studies on the relationship of costs of operation with city size will also be consulted (Alonso, W. [1971] "The Economics of Urban Size." Papers of the Regional Science Association 26: 61-76; Klaassen, L. H. [1972] "Growth Poles in Economic Theory and Policy," in A. Kuklinski and R. Petrella eds. Growth Poles and Regional Policies. The Hague: Mouton, pp. 1-40; and Richardson, H. W. [1973] The Economics of Urban Size. Lexington, Mass.: D. C. Heath.

B. Economic Impacts

Energy development brings with it other economic activity which either uses its energy output or provides inputs (such as materials and services) to the energy development. These relationships among economic sectors are measured by input-output models, which for given areas provide indicators such as income and employment multipliers. These models measure the long-run effect of a change in one sector, such as coal mining, on all other sectors of the economy, through both direct and indirect buyer-seller relationships. Where suitable, state and substate input-output models will be utilized for comparison of estimates of energy sector multipliers; these multipliers will be used to compare estimates for the additional long-run employment (and population) generated in each sector as a result of an expansion in energy production.

New revenues may become available to local governments from property taxes on facilities, and through income and sales taxes from employees. These revenues and how they are used by governments involve policy analysis inputs (see Chapter 5). In addition, where people new to the area choose to live may alter existing patterns of commuting and shopping, and these may cause new commercial activities in the area. These changes will be related to the spatial population distribution and impacts on these local activities will be assessed.

During the first year of the study, employment projections will be made with existing or arbitrary multiplier estimates. However, such values vary widely and there is potential for considerable error in this approach. In the second and third years, employment multipliers may be estimated with relatively new techniques suitable for localities in rural areas.[1] The sensitivity of forecasts to multiplier estimates will then be assessed.

C. Cultural Impacts

The environment surrounding many towns in the West and their relative isolation have formed a life-style that will necessarily be changed as newcomers arrive to exploit energy resources. Ethnic groups which have been able to maintain a relative isolation will be severely affected by the different values and cultures of the new population.

Land use impacts, including new demands for urban land, transportation routes, and new pressures on recreational land,

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[1]Braschler, C. (1972) "A Comparison of Least-Squares Estimates of Regional Employment Multipliers with Other Methods." Journal of Regional Science 12: 457-468; Mathur, V. K., and H. S. Rosen (1974) "Regional Employment Multiplier: A New Approach." Land Economics 50: 93-96; Rosen, H. S., and V. K. Mathur (1973) "An Econometric Technique versus Traditional Techniques for Obtaining Regional Employment Multipliers: A Comparative Study." Environment and Planning 5: 273-282.

are also likely to cause conflicts between traditional Western life-styles and those of the new residents. These impacts will be described and assessed with the help of existing studies of such impacts. These studies tend to emphasize the satisfactions (and dissatisfactions) of local residents with such intangible elements as the supportive spirit of the community, responsive government, and adequate leisure time activities.[1]

The time lag between the arrival of new residents and the provision of services can also induce stresses in the society. For example, dissatisfaction with inadequate services can create a malaise in both old and new residents. Conflicts between the two groups may arise due to segregation of the two groups in a community. Distinction between construction and operation phases will be important here, since the temporary nature of construction employees' residence in the community may itself give rise to these and other conflicts. New demands and uses for land will be estimated from expected needs for urban, industrial, transportation, and recreation development. Conflicts with existing uses, especially with agricultural land and wildlife habitat, will be described and assessed.

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[1]Gilmore, J. S., and M. K. Duff (1974) A Growth Management Case Study: Sweetwater County, Wyoming. Denver: University of Denver Research Institute; Institute for Social Science Research (1974) A Comparative Study of the Impact of Coal Development on the Way of Life of People in the Coal Areas of Eastern Montana and Northeastern Wyoming. Missoula, Mont.: University of Montana, Institute for Social Science Research.

D. Political and Governmental Impacts

Impacts on governmental and institutional arrangements and on patterns of political participation are likely to occur from energy development. Three categories of governmental activity which may be affected in various ways include:

1. Policy management, which includes the identification of needs, analysis of options, establishment of priorities, allocation of resources, and the implementation of policies, strategies, and programs.

2. Resource management, which is the establishment of basic administrative support systems, such as budgeting, financial management, personnel administration, and information management.

3. Program management, which is the daily operation of public services in functional governmental units.[1]

Greater service needs (as well as financial alternatives to meet these needs), long-range planning needs for zoning and other development regulations, and the need for additional coordination among the different jurisdictional levels of government will increase demands within these three public management categories. Most of these demands will be caused by the creation of new settlement areas and the introduction of new industry and recreation facilities in what were predominantly rural areas. Residents of these areas will demand a richer mix of public services and conveniences, expect better quality services, and create more groups dependent on public support. As a result, state and local

[1]Study Committee on Policy Management Assistance (1975) Strengthening Public Management in the Intergovernmental System. Washington, D.C.: U.S. Government Printing Office.

governments will be pressed to match these rising demands with growth in their fiscal and administrative capacities. In addition, pressures will be experienced in terms of program needs: for example, crime, sanitation, health, and public welfare.

Closely related to the management of government is the degree and type of public participation in formal and informal governing groups. Until the recent past, participation was limited largely to user groups. New groups, dissatisfied with this arrangement, are seeking ways to inject their values into the decision process.[1] The political considerations which will be examined include the public and industry groups active in the area; an assessment of the participants, their organization, and relative influence; the structure of government personnel policies (elected--professional or part-time--and appointed officials), and potential political conflicts between segments of the electorate. For example, class differences, rural-urban differences, and pro-con development attitudes may exist even before new residents arrive and perhaps shift the political base of the area. Belief in and support for the form and style of government, whether slower, more traditional, or responsive and expedient can shift when the population changes.

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[1]For example, see Bolle, Arnold N. (1971) "Public Participation in Environmental Policy." Natural Resources Journal 11 (July): 497-505; Curren, Terence P. (1971) "Water Resources Management in the Public Interest." Water Resources Bulletin 7: 33-39; Rocky Mountain Environmental Research: Quest for a Future (1974) Task Force on Institutional Arrangements, Final Report. Logan, Utah: Utah State University, Ecology Center, pp. II-C-10, II-C-11.

Impacts on the local power base, governmental structure, and institutional arrangements for decisionmaking will also be described and analyzed.[1] Potential effects on political groups and governments at other than the local level will also be identified.[2]

Another important consideration in this impact category is the planning capability of the community in terms of the existence and size of a planning budget, the number and expertise of personnel, identification of the responsible coordinating agency, and a description of development plans already in existence.

4.5.4 Anticipated Results

Projections of population, housing, educational needs, and other characteristics will result in values which are functions of time and can thus be graphed.

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[1]For a discussion and collection of much of the literature on institutional power arrangements relative to differing political administrative forms, see Downes, Bryan T., ed. (1971) Cities and Suburbs: Selected Readings in Local Politics and Public Policy. Belmont, Calif.: Wadsworth; Clark, Terry N., ed. (1968) Community Structure and Decision-Making: Comparative Analyses. San Francisco: Chandler Publishing Company; Lineberry, Robert L., and Edmund P. Fowler (1967) "Reformism and Public Policies in American Cities." American Political Science Review 61: 701-716; and Liebert, Roland J. (1974) "Municipal Functions, Structure, and Expenditures: A Reanalysis of Recent Research." Social Science Quarterly 54: 765-783.

[2]Demands on policy and program management at the local and state level are bound to spill over into intergovernmental jurisdictions, involving both regional and federal resources.

These graphs will include error ranges identifying the uncertainty inherent in the projections. Any input-output model projections of energy-related economic activity will have to be aggregated according to the future timing and sequencing of various sectoral expansions. Land use, population concentrations, and other changes will be presented both verbally and by means of maps. Descriptive or qualitative projections of, for example, social relationships, cultural differences, political activity, and government structure can be described as trends over time or as cross-sectional changes to indicate the patterns of change.

Sensitivity analyses will be employed to identify those impacts which are relatively constant and those which are highly dependent upon the conditions and assumptions of the analysis. Those variables which are most influenced by other impacts are also most likely to be sensitive to error ranges and varying assumptions.[1]

4.5.5 Data Adequacy

Many data are available from U.S. Bureau of Census publications and from state statistical abstracts and reports. Information on recent trends (since 1970) is generally only available from such

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[1] Although this section considers both qualitative and quantitative data, only quantitative characteristics are generally amenable to sensitivity analyses. Changes in descriptive variables due to other influences may be noted, but numerical ranges are not generally appropriate.

local studies; sources for some scenario areas are continually being acquired and updated. Data on government revenues and expenditures are also compiled by both the Census Bureau and the states, but such detailed items as health care, utilities, amenities, life-style, parties-at-interest, and laws and regulations must be gathered from a large number of separate reports and other sources, including individuals knowledgeable about some aspect of these conditions. A great deal of reliance will have to be placed on local studies, especially those which document social attitudes, cultures, and concerns.

4.5.6 Research Adequacy

Extant research on energy-related socioeconomic impacts in the western U.S. is not very uniform in coverage. A great deal of research of varying quality is available for many areas of the West, from large regions to small local areas. These studies, however, do not always correspond in coverage to our scenario sites. These studies include a variety of site-specific socioeconomic data, descriptions, and survey information. This type of information, especially the attitudes and life-styles of local inhabitants, is needed for our TA to include a reasonable social impact assessment at either the local or regional scenario level. Further, relatively little research[1] apparently has addressed the adjustments which local individuals, groups, and governments must make when energy impacts are anticipated or felt. The identification of, and distinction between, irreversible and manageable impacts on existing energy-impacted towns also would be useful to this research effort.

4.6 HEALTH EFFECTS

4.6.1 Introduction

The primary purpose of the health effects impact analysis is to identify and provide a preliminary evaluation of the potential effects on human health of the energy development activities considered in the scenarios. The output of this section will consist of descriptions, primarily in qualitative terms, of the occupational and public health risks involved in the scenarios so that policy issues related to health hazards can be identified. Judgments will be made concerning the possible health impacts associated with each development site, as well as the larger regions within the categories listed in Table 4-8.

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[1] Federation of Rocky Mountain States (1975) Energy Development in the Rocky Mountain Region: Goals and Concerns. Denver: Federation of Rocky Mountain States; and Gilmore, J. S. and M. K. Duff (1974) A Growth Management Case Study: Sweetwater County, Wyoming. Denver: University of Denver Research Institute (December).

TABLE 4-8: HEALTH EFFECTS IMPACT CATEGORIES

Impacts of "criteria pollutants" on public health, under worst-case, long-term, and short-term average conditions, with respect to: Population geography Age structure Occupational exposure Pathways by which people are exposed to pollutants through air, fluid and solid vectors. Potential cumulative, antagonistic, and synergistic effects of pollutants. Qualitative hazard associated with "noncriteria pollutants" Trace elements Atmospheric sulfates Hydrocarbons Radioactive emissions

A secondary objective is the identification and assessment of models and other tools available to the health specialist for projecting health outcomes in exposed populations. The adequacy of the data base for performing this task, and future research needs in health effects from residuals of energy technologies, will also be delineated.

4.6.2 Baseline Data

The health effects analysis uses as its input data the results of the socioeconomic and air-quality modelling tasks, as well as information contained in the ERDS's relating to production of such nonregulated pollutants as potentially carcinogenic hydrocarbons. Baseline data on the incidence of respiratory disorders, cancers, or background incidence of similar disabilities, is generally not available at an appropriate level of detail for use in local or aggregated scenarios.

4.6.3 Methods and Procedures

The underlying framework in the health effects analysis involves tracing the pathways of pollutants from their point of emission through the salient elements of the biosphere in order to identify exposure interfaces with the human population. The goal of this process is to identify points along the pathway of selected pollutant species (see Table 4-9) and to identify relative hazards levels of these pollutants. Following pollutants along their pathway through the physical and biological elements

TABLE 4-9: SELECTED HAZARDOUS AGENTS ASSOCIATED WITH TECHNOLOGIES

Oil	Coal	Oil Shale	Geothermal	Uranium
Emissions of sulfur oxides to the atmosphere Conversion of emitted sulfur oxides to sulfates* Emissions of particulates to the atmosphere Toxic metals constituents of particulate emissions, including lead, mercury, and vanadium*	Emissions of sulfur oxides to the atmosphere Atmospheric conversion of sulfur oxides to sulfates* Emissions of particulates to the atmosphere Discharge of light hydrocarbons and possible secondary effects in the atmosphere* Emissions of polynuclear aromatics to the atmosphere Effects of metal-containing catalysts that may be used in the conversion process Toxic metal constituents of particulate emissions including mercury and lead as well as radioactive materials naturally occurring in coal such as Radium-226* Hazards associated with disposal of ash that might contain toxic metals* Hazards associated with disposal of ash that may contain toxic or radioactive metals*	Effects of emissions of polynuclear aromatics* Effects of discharges of heavy metals and radionuclides naturally occurring in the oil shale* Effects of emissions of silica during processing* Possible health effects of disposal residue from processing to obtain oil*	Effects of emissions of hydrogen sulfide and volatile mercury to the atmosphere* Effects of emissions of arsenic and mercury in condensed water* Effects of the emission of gaseous radionuclides such as Radon-222 to the atmosphere and metallic radionuclides such as Radium-226 which may be discharged to surface water or reinjected*	Additions of radionuclides and heavy metals to neighboring surface and groundwaters* Release of airborne radioactive dusts from ore piles, tailings retention systems and ore crushing and grinding ventilation systems* Release of radon gas from leach tanks, ore piles, tailings retention systems and ore crushing and grinding systems* Release of dissolved radionuclides from tailings pond(s) to neighboring surface and groundwaters* Release of nonradioactive heavy metals and sulfur compounds to air and water*

(Asterisk indicates only qualitative estimates of ambient concentrations are available as input data.)

of the biosphere is expected to produce results which can be used to develop control strategies and policy recommendations.

The results of pollution transport modeling provide the initial concentrations of criteria pollutants which constitute specific health hazards. As described in Section 4.1 on pollution transport modeling, this input information will be in the form of:

1. Maps of average annual concentrations of criteria pollutants at the plant boundary, over the town, and where possible, on a larger regional scale as the models permit.

2. Worst-case conditions data within one hour, three hour, eight hour, twenty-four hour, and four day, time frames.

3. Natural background concentration of selected hazardous agents at the plant facility, over the townsite, and over the region as data are available.

The socioeconomic impact analysis will provide data on the characteristics of the population that are essential to evaluate the effects of pollutant concentrations. For example, the spatial distribution of the potential receptor population and the age distribution are needed to evaluate the susceptibility of the population to both acute and chronic exposure of pollutants.

When these baseline data have been gathered, pollutants will be reviewed systematically and the hazards associated with the proposed technologies will be identified. The primary approach used to accomplish this assessment will be pathway analysis which is the systematic tracing of the form of toxic substances through air, fluid, and soil vectors and biological components in order to determine the exposure interfaces with human populations. Systematic tracing also facilitates the identification of potential situations where cumulative, antagonistic, or synergistic effects may take place.

The specific identification of the extent of health hazard will be based on literature review and informed judgments of the health consultants by relating present understanding of dose-response relationships to ambient levels determined in the scenarios. Where recognized models are not available, linear extrapolations of dose-response relationships may be used where these appear reasonable. This form of assessment will be applied to both construction and operation stages of the site-specific scenarios. It is expected that significant portions of this analysis, however, will be limited in terms of available knowledge, and one of the objectives will be to identify significant gaps, especially in terms of the etiology and epidemiology of pollution-induced stresses.

4.6.4 Anticipated Results

The major emphasis will be on hazards to human populations from exposure to emissions from energy facilities. In most cases, it is expected that only an upper boundary of maximum expected health impacts can be established. The full range of potential dose-effect relationships is outside the scope of this study.

As in other sections of the impact analysis, this portion of the assessment will be a synthesis: bringing together previous and on-going studies and ordering them in terms of these needs of the TA.

4.6.5 Data Adequacy

As indicated in the previous section on methods, outcomes of environmental stresses will be analyzed on the basis of available literature in toxicology (experimentation with doses on laboratory animals) and epidemiology (disease patterns determined by statistical associations in human populations) as well as clinical work (experiments on volunteer human subjects) and by accidental occupational exposures. Much of the evaluation will be based on criteria and standards developed by the EPA, the National Institute of Occupational Safety and Health (NIOSH) and the Occupational Safety and Health Administration (OSHA) together with the experience of the health research consultants conducting this section of the study. These consultants, currently at the School of Public Health at the University of Texas Health Science Center at Houston, Texas, are:

Dr. Stanley M. Pier, Ph.D., Purdue University
(organic chemistry)
Associate Professor of Environmental Health

Dr. Richard K. Severs, Ph.D., University of Texas
(community health)
Assistant Professor of Environmental Health

Dr. Thomas F. Gesell, Ph.D., University of Tennessee
(physics and health physics)
Assistant Professor of Health Physics

4.6.6 Research Adequacy

As previously identified, significant data gaps exist in identifying the cause-effect relationships between chronic and acute exposure and pathological response in human populations. A significant part of the first year effort will be to flag these limitations and to suggest areas where additional research would produce useful results. In addition, judgments will be made on the quality of both the available data and the predictions made in the study.

4.7 ENERGY

4.7.1 Introduction

The energy impacts of energy development can be analyzed using energy analysis, or as it is sometimes known, net energy analysis. This is a technique which accounts for the energy costs of finding, extracting, upgrading, and delivering a commodity (in this case a fuel) to the consumer. The goal of energy development in the West is to supply energy to consuming sectors, either directly as fuel or for the production of goods. It is, therefore, useful to know how much of the energy initially available must be fed back to the energy developments themselves.

Although the usefulness of energy analyses is controversial, any evaluation which purports to analyze a full range of impacts requires that energy analysis be taken into account. Selected energy resource systems and several levels of development will be compared on the basis of their net energy. It is possible that the difference in net output between high and low energy development will be a small fraction of the gross difference, a fact that may have important policy implications.[1]

4.7.2 Baseline Data

There are currently three sets of procedures for doing energy analysis, each requiring slightly different baseline data. In all three cases, the direct energy requirements of each technology are needed. In addition, physical (that is, tons of steel, cement, etc.), economic (that is, expenditures for steel and cement, etc.), and environmental (that is, land and water) input data are needed as well as coefficients for converting physical inputs and costs to energy units. Preliminary data on both a physical and cost basis for each technology are to be included in the ERDS data base, and will be updated in the second and third years. Many other studies also will be drawn upon for the needed data. Coefficients for converting physical quantities to Btu's are difficult to obtain,[2] but coefficients for converting costs

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[1] Gilliland, Martha W. (1975) "Energy Analysis and Public Policy." Science 189 (September 26): 1051-1056.

[2] Some sources are: Berry, R. S., and M. F. Fels (1973) "The Energy Cost of Automobiles." Bulletin of Atomic Scientists 29 (December): 11-17; and Makhijani, A. B., and A. J. Lichtenberg (1972) "Energy and Well-Being." Environment 14 (June): 10-18.

to Btu's are readily available in 1967 dollars.[1] The cost-to-Btu coefficients, known as Herendeen coefficients, require the use of deflators to bring costs down to 1967 dollars. Deflators are available from the Department of Commerce.[2] Data required to evaluate environmental impacts are included in the ecological impact analysis.

4.7.3 Methods and Procedures

All three sets of energy accounting procedures evaluate the energy embodied in materials and equipment, either by physical units (Btu's per ton) or economic units (Btu's per dollar). One of the three sets of procedures also includes environmental inputs to the process[3] and requires ecological impact information. The value of environmental inputs goes beyond the price of the land and water and includes services the environment contributes without charge.

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[1]Herendeen, R. A., and C. W. Bullard (1974) Energy Cost of Goods and Services, 1963 and 1967. Urbana, Ill.: University of Illinois, Center for Advanced Computation.

[2]Deflators are published annually by the U.S. Department of Commerce in the July issue of Survey of Current Business.

[3]For a discussion of this concept, see Gilliland, Martha W. (1975) "Energy Analysis and Public Policy." Science 189 (September 26): 1051-1056.

Energy accounting using these three procedures will be a continuing effort; however, results given in the first year TA will draw exclusively from existing and ongoing analyses of other research groups.[1] Beyond the first year, specific strings of modules described in the scenarios will be analyzed to the extent that data have been compiled and/or are available from secondary sources.

4.7.4 Anticipated Results

Total energy input in the form of the direct energy and materials required for selected technologies, combinations of technologies, and the developments postulated in the scenarios will be tabulated and compared with the total energy output of each.

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[1]Some of these include, for oil shale development: Raese, Jon W., ed. (1975)"Proceedings of the Eighth Oil Shale Symposium." Quarterly of the Colorado School of Mines 70 (July); for coal, natural gas, oil shale, and geothermal: on-going ERDA-sponsored research at Development Sciences, Inc., East Sandwich, Mass. and on-going Department of the Interior-sponsored research at Colorado Energy Research Institute, Golden, Colo.; for geothermal, Gilliland, Martha W. (1975) "Energy Analysis and Public Policy." Science 189 (September 26): 1051-1056; for uranium mining and milling: Rieber, Michael, Shao Lee Soo, James Stukel (1975) The Coal Future: Economic and Technological Analysis of Initiatives and Innovations to Secure Fuel Supply Independence. Urbana, Ill.: University of Illinois, Center for Advanced Computation; Freim, James B. (1975) "Energy Analysis of the Milling Proces in the Nuclear Fuel Cycle," in Energy and the Environment, Vol. I. Proceedings of the 21st Annual Technical Meeting, Institute of Environmental Sciences, Anaheim, Calif., April 14-16.

4.7.5 Data Adequacy

The extent to which input data on both a physical and cost basis will be included in the ERDS is still uncertain. Data for converting physical quantities to Btu's are completely inadequate, a fact which may preclude this sort of direct analysis. Data for converting costs to Btu's are outmoded in that they have been tabulated only through 1967. Using 1967 dollars and deflators introduces an error in the range of 25 percent.

4.7.6 Research Adequacy

Several gaps in both the data base and analytical techniques limit accurate calculations of energy inputs. Data base gaps have been identified above. An important research need is the compilation of energy cost data on a Btu's per ton of product basis. Furthermore, the theoretical basis of the analytical techniques has not been clearly delineated. The relationship of this theory, which is based on the laws of thermodynamics, to economic theory and economic analysis is unclear and controversial. A research project which did both economic and energy analyses of the same developments under the same assumptions would help resolve the controversy and provide insight into the different kinds of information obtainable from each type of analysis. Finally, research on both the theoretical basis and procedures for evaluating environmental inputs is needed.

4.8 AESTHETIC IMPACTS

4.8.1 Introduction

Some of the issues that will result from energy development activities arise because of impacts on aesthetic values or goals. Aesthetic impacts are associated with those particular quality of life perceptions that individuals (or groups) emphasize or select as related to beautiful and/or pleasing aspects of the natural environment and the physical man-made environment. These impacts occur largely because of physical alternations and might therefore appropriately be considered in other impact sections. However, increasingly, noneconomic and nonmaterial concerns are expressed when development projects are assessed. Therefore, to insure that the subjectivity and diversity of aesthetic experiences are properly considered,[1] a separate brief section is devoted to the description and assessment of potential changes in aesthetic opportunities resulting from energy resource development.

In this TA aesthetic impacts will be limited to treatment of potential changes in both the natural and man-made landscape and to water, air, noise, and biological surroundings, primarily as

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[1]The point to be emphasized here is that it is not just the outward physical phenomenon or event that must be considered, but its connective relationship with emotion, perception, and appreciation. In this sense, aesthetic opportunities are tied to a deeper sense than what is simply considered economically worthwhile, or pragmatically effective. See Dewey, John (1927) The Public and Its Problems. Chicago: The Swallow Press, Inc., pp. 182-184.

perceived from residential, commercial, and recreational areas. (See Table 4-10.)

4.8.2 Baseline Data

Data for aesthetic impacts will come from scenario descriptions and the analyses of physical, ecological, and social impacts. These data will include, for example, changes in air and water quality, landscape, noise levels, skyline due to the construction of man-made objects, floral and faunal changes, and changes in population levels associated with increased urban development. Information on aesthetic preferences must be extrapolated from available attitude survey material for the western states.

4.8.3 Methods and Procedures

The extreme variations in aesthetic judgments make direct impact assessment impossible. This stems from the fact the things people consider aesthetically worthwhile, significant, or good do not gain their significance or value from some empirical measure of effectiveness. Rather, they are a product of the emotive experience of seeking and enjoying what is beautiful. While aesthetic goals themselves are thus inherently nonquantifiable, they are, like other preference values, in some sense hierarchically perceived by individuals, parties-at-interest, and decisionmakers.

Since this technology assessment is a research effort based on secondary sources, the aesthetic impact analysis must rely on completed and ongoing studies in the western states. However, the only substantive area in which research procedures have been applied to aesthetic goals is in the field of water resources planning.[1] Efforts in this area have employed a content analysis of survey interviews concerning the aesthetic preferences of parties-at-interest. Such techniques require extensive questioning of people and the construction of sophisticated social indicator indices which must be mathematically linked to perceived but nonquantifiable aesthetic goals. Consequently, the procedures used in this TA will be limited to an effort to assess qualitatively aesthetic factors by relating a range of aesthetic values extrapolated from available attitude surveys to energy developments postulated in the scenarios. This will be done by obtaining a team consensus about those physical impacts described in the scenario analyses which represent potential alterations of aesthetic opportunities (as shown in Table 4-10). Some impacts may be straightforward, for example, the presence of untreated

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[1]See Andrews, Wade H., Rabel J. Burdge, Harold R. Carpenter, W. Keith Warner, and Kenneth P. Wilkinson, eds. (1973) <u>The Social Well-Being and Quality of Life Dimension in Water Resources Planning and Development</u>. Proceedings of the Conference of the University Council on Water Resources, Utah State University, Logan Utah, July 10-12; and Water Resources Research Center of the Thirteen Western States, Technical Committee (1974) <u>Water Resources, Planning, Social Goals, and Indicators: Methodological Development and Empirical Test</u>. Logan, Utah: Utah State University, Utah Water Research Laboratory.

waste or sewage in a lake or a stream. Others, such as local attitudes about a newly constructed energy facility's effect on the surrounding landscape, are not as readily identifiable. Once a range of values is established, those impacts ranked high according to a number of potential criteria will receive particular attention, although all aesthetic impacts will provide some information to be used in policy analysis.

TABLE 4-10: AESTHETIC OPPORTUNITIES IMPACT CATEGORIES

Landscape	Land forms, geologic surface material, urban, mountain, desert, agricultural, forest, water-land interface characteristics.
Air	Visibility, odor, eye irritants
Water	Clarity, odor, surface characteristics (floating objects), water-land interface characteristics.
Biota	Vegetation, fauna, number, location, and variety of species.
Noise	Unpleasant intermittent or background sounds.
Man-made Objects	Visual, condition, consonance with environmental surroundings, color.

Source: Based on categories developed by Whitman, Ira L., and others (1973) "A Description of an Environmental Evaluation System," in Environmental Protection Agency (ed.) The Quality of Life Concept: A Potential New Tool for Decision-Makers. Washington: Environmental Protection Agency, Office of Research and Monitoring, Environmental Studies Division, p. II-147; and Water Resources Research Center of the Thirteen Western States, Technical Committee (1974) Water Resources Planning, Social Goals, and Indicators: Methodological Development and Empirical Test. Logan, Utah: Utah State University, Utah Water Research Laboratory.

4.8.4 Anticipated Results

It is expected that many of the visual intrusions (for example, the introduction of an energy facility on what was once a "wide open" expanse of range land) could rank high on the list of aesthetic impact, but factors that are traced from other sources in impact analysis might also be significant. For example, secondary changes could be important, such as reductions in game or species variety as a result of habitat attrition, or changes from increased human population that would jam park lands, produce litter, or change the characteristics of clear streams. Ranking of potential results will be largely affected by the range of aesthetic values used in assessing impact.

4.8.5 Data Adequacy

Data for this section of the assessment are grossly inadequate. Aesthetic preference data are either inadequate or not available for most of our scenario sites. Furthermore, the reliability of available survey data is frequently questionable. Some data have been gathered that deal with quality of life intrusions on Indian aesthetic and religious values as a result of energy development.[1] In addition, as noted above, efforts have been

[1] Goodman, James M. (n.d.) "Some Observations of the Navajo Sense of Place." Unpublished paper, University of Oklahoma, Department of Geography.

undertaken to develop social indicators for aesthetic opportunities reflected in water resources planning and development.

4.8.6 Research Adequacy

Research on aesthetic values relative to energy facility configurations has not been accomplished. Because of its subjective nature, the perception of goal achievement does not allow pure objective measurements. Furthermore, indices that have been developed and used to describe aesthetic impacts for other areas of inquiry are constrained by a lack of transference. In part, this is due to the incomplete theoretical nature of social indicator methodology. But even where indices have been constructed, they are, in the final analysis, the product of informed judgment, whether obtained through sophisticated social indicator procedures or by review panel processes. And they usually are problematical in that they are understood only by those experts who develop them and not by the decisionmaker who would like to use them to reduce uncertainty regarding aesthetic goals in the planning process.

4.9 INTEGRATING THE RESULTS OF THE IMPACT ANALYSES

The impact analyses described above are shaped by the nine scenarios being assessed in this TA. It should be recalled that two kinds of scenarios have been constructed, site-specific and aggregated. Both are intended to facilitate the identification and analysis of a broad spectrum of impacts, problems, and issues during the first year of the TA. The six site-specific scenarios provide hypothetical combinations of particular technologies deployed at specific sites. These provide a basis for assessing impacts and identifying problems and issues that have, or are likely to, arise: (1) on a local level; (2) when development takes place under particular kinds of conditions; and (3) when specific processes or technologies are deployed. Each scenario includes two phases of development, construction and operation,[1] and three time periods: present to 1980, 1990, 2000.

The three aggregate scenarios to be assessed include one regional and two river basin scenarios. The regional scenario provides for two levels of development (high and low) for the three time periods. The river basin scenarios address only one level of development. The aggregate scenarios relate national energy demand projections to the resulting demands for the development of western energy resources. This provides for the identification of proposed levels of development; and it permits an assessment of the national impacts of these levels of development.

The extent to which development trends and synergisms may be identified in the analysis of these nine scenarios depends on the

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[1]A third phase, termination, is considered but will not be emphasized in the first year report.

results of the impact analyses described in this chapter.

Scenarios and impact analyses are expected to illuminate impacts:

1. associated with a particular phase of development--construction, operational, and, in years two or three, termination;

2. associated with the three time periods--the present to 1980, 1990, 2000;

3. resulting from unique characteristics possessed by a particular scenario--for example, differences in social, economic, ecological, or political conditions; and

4. resulting from synergistic effects among different impacts.

The aggregated scenarios will produce results which highlight:

1. aggregated impacts at a river basin and regional level;

2. the national impacts of two levels of regional energy development--for example, on materials and equipment; and

3. interactive effects and effects of scale.

CHAPTER 5

THE INTEGRATIVE PHASE: POLICY ANALYSIS

5.1 INTRODUCTION

As stated earlier, technology assessments (TA) are undertaken to provide policymakers a better understanding of the consequences likely to result from their decision to introduce, extend, or modify a technology. This TA of western energy resource development is intended to provide national, regional, state, and local policymakers a better understanding of the consequences of various patterns, rates, and levels of western energy resource development. Chapters 3 and 4 describe the data base that will provide policymakers organized information on the inputs and outputs of various patterns, rates, and levels of energy development (Chapter 3) and systematic impact analyses intended to inform policymakers concerning the impacts likely to be produced by these developments (Chapter 4). While these products provide policymakers more information, by themselves they are inadequate to accomplish the overall purpose of a TA. Impacts, whether real or imagined, frequently give rise to problems and issues, at least some of which policymakers attempt to resolve. In such cases, interests and values are almost always in conflict and have to be accommodated. For their plans and policies to be well-informed, policymakers need to know about these conflicts and how alternative patterns, rates, and levels of development will affect them. In the Integrative Phase described in this chapter, the results of the various qualitative and quantitative analyses described above are integrated in an analysis of problems and issues. These integrating analyses relate the Descriptive and Interactive Phase products described in Chapters 3 and 4 to the social, economic, and political context within which policymakers make plans and policies.[1] The product of these analyses will indicate how various policy alternatives are expected to affect the interests and values that are at stake, suggest how accommodations might be reached in policymaking structures and institutions, and describe the likely social, economic, political, and environmental consequences of various development alternatives. Finally, the Science and Public Policy (S&PP)-Radian research team will make policy recommendations, primarily to the Environmental Protection Agency (EPA), but, when appropriate,to other federal agencies, to other levels of government, and to regional intergovernmental organizations as well. The approach, procedures, methods, and techniques to be used in the conduct of these policy analyses are described in the following sections.

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[1]The procedures and methods of analysis to be used are described in Section 5.3.

5.2 GENERAL APPROACH TO POLICY ANALYSIS

As explained in the conceptual framework described in Chapter 2, impacts occur when the inputs and outputs of a technology interact with the conditions which exist where the technology is deployed. Given the impacts that have been anticipated and those determined using the analytical techniques described in Chapter 4, the next step is to decide which of these impacts warrant further attention. Policy analyses are undertaken to assess and compare alternatives for dealing with the problems and issues which arise as a consequence of these impacts. Note that the interdisciplinary team has several difficult decisions to make: first, it has to decide which problems and issues are significant enough to warrant further analysis; second, it has to decide what the policy alternatives and implementation strategy options are;[1] and third, it has to decide which of these options are feasible and should be assessed.[2] These decisions are critical because they determine, to a very great extent, the

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[1]Implementation strategies include determining the appropriate policy institutions and structures. In the case of public policies, this would be the description of the appropriate level, branch, department, agency, or intergovernmental organization. Nongovernmental institutions and structures that are important in making particular kinds of public policy are also considered.

[2]As noted in Chapter 2, criteria of feasibility will be made explicit in each analysis. This will necessarily require the team to forecast future states of society when such things as social values and the relative political strength of participants within the policymaking system may have changed. The point is that, based on the same criteria, what is feasible in 1980 and in the year 2000 may differ significantly.

nature and quality of the research results that will be produced by the assessment. Unfortunately, there is neither a well-defined, empirically tested TA theory nor a generally agreed upon TA methodology that can be relied upon to insure that the team will make good decisions. This is why the interdisciplinary team approach, including the extensive use of external reviewers is stressed. Both are a means for attempting to insure that all germane factors are considered and that appropriate criteria and standards are applied. In short, the procedural approach described in this section is basically a substitute for the lack of established TA theory and methodology.

Reviews by the interdisciplinary team and external reviewers are intended to overcome inherent limitations such as bias, narrowness of perspective, and insufficient knowledge. The goal is to see to it that these limitations are not allowed to go unchallenged. When team members are drawn from a variety of disciplines and encouraged to develop an intellectually challenging working environment, the team as a group is less likely to permit the limitations of individual team members to shape the assessment. But, since there is an upper limit on the number of persons that can be included in an interdisciplinary research team, limitation in terms of perspective, bias, and knowledge cannot be completely overcome. This, together with the possibility that the team has an institutional bias, is why a variety of external review mechanisms are an integral part of the S&PP-Radian team's approach. External reviewers include consultants, an advisory committee and a broad range of persons chosen to represent the interests or values that are at stake.

Consultants are selected to perform two primary functions: to provide perspectives and expertise not available within the interdisciplinary team; and to provide in-depth critiques of various papers and reports produced by the team.

The advisory committee is constituted to provide for balanced representation of the interests and values at stake. In energy resource development, for example, these might well include representatives of industry, labor, Indian tribes, various levels of government, and so forth. Members of the committee are expected to provide a communications link between the interdisciplinary team and the community of interests that the committee member was chosen to represent.

To be manageable, the size of the advisory committee must be limited. Therefore, it is unlikely that all interests or values that the team should consider get represented. Consequently, on the basis of its own knowledge and the advice of the advisory committee and others, a broad range of other external reviewers are asked to critique the interdisciplinary team's papers and draft reports. Many of these are parties-at-interest, but some of these reviewers are selected because they possess expertise which the team wishes to utilize.

An operational example is the case of the October 31, 1975 draft of this work plan report. More than 400 copies were distributed to: (1) alert a broad range of potentially interested parties that this TA is underway; (2) encourage them to comment ; on the draft work plan and to suggest how it might be improved (3) identify sources of data, analyses, and expertise; and (4) to identify and promote cooperation with other researchers whose research might be used in this TA. The results were useful and contributed to the achievement of all four objectives. This "First Year Work Plan Report" incorporates many of the suggested changes.

The procedures to minimize bias, broaden perspective, and overcome knowledge deficiencies described above are displayed in Figure 5-1. In the S&PP-Radian team's approach, these procedures are applicable to every phase of a TA, but only their specific application to policy analysis will be described. The following description of general procedures include an identification and description of various analytical methods and techniques to be used to evaluate and compare the costs, risks, and benefits of policy alternatives and implementation strategies.[1]

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[1]For more details on the interdisciplinary team approach, see Kash, Don E., and Irvin L. White (1971) "Technology Assessment: Harnessing Genius." <u>Chemical and Engineering News</u> 49 (November 20): 36-41; and White, Irvin L. (1975) "Interdisciplinarity," pp. 87-96 in Sherry P. Arnstein and Alexander N. Christakis (eds.) <u>Perspectives on Technology Assessment</u>. Columbus, Ohio: Academy for Contemporary Problems. A common criticism of this approach is that it is time consuming and expensive. It is both. But to date this approach appears to have produced results that have had a greater impact on policymaking than any other approach to TA. See Miedema, A. <u>RANN Utilization Experience: Outer Continental Shelf Oil and Gas</u>,

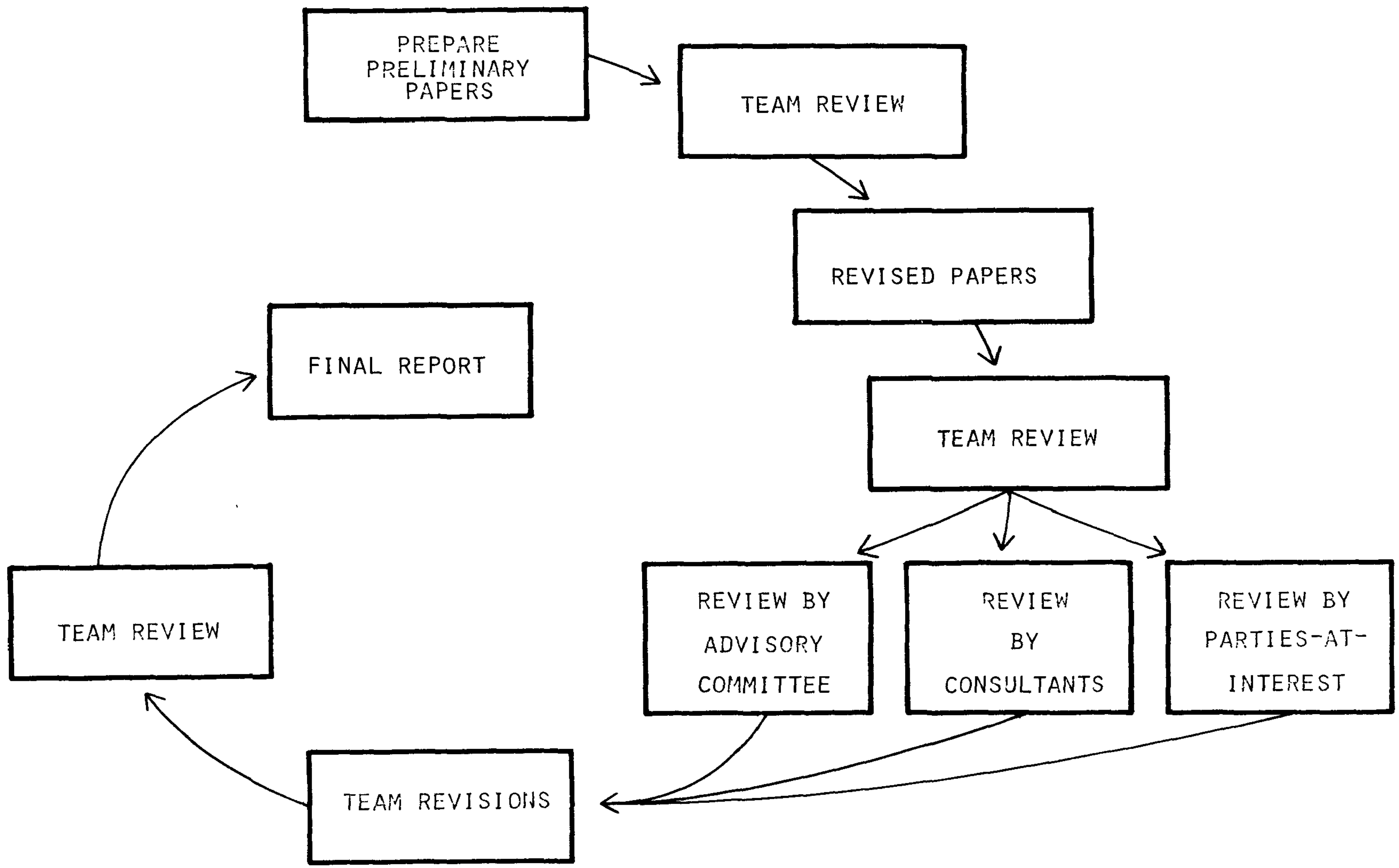

Figure 5-1: Internal and External Review Processes

5.3 PROCEDURES, METHODS, AND TECHNIQUES

Using the general approach to policy analysis described in the preceding section, the interdisciplinary research team conducts policy analyses in four steps:

1. The identification and definition of problems and issues;
2. The identification and description of policy alternatives and implementation strategies;
3. The determination of the costs, risks, and benefits associated with each alternative and strategy; and
4. The identification of the alternative and strategy that would maximize "net value expectation;"[1] and the recommendation of policies and implementation strategies.

To be comprehensive, the analyses would have to encompass all problems and issues and identify, evaluate, and compare all policy alternatives and implementation strategies.[2] As mentioned earlier, even if this were possible it generally is not practical.

University of Oklahoma, Case Study No. 12. Research Triangle Park, N.C.: Research Triangle Institute.

[1]See Haveman, Robert H. (1970) The Economics of the Public Sector. New York: John Wiley. "Net value expectation" means that all relevant values are known and that any sacrifice in values is more than compensated for by gains in other values. See also, Dye, Thomas R. (1972) Understanding Public Policy. Englewood Cliffs, N.J.: Prentice-Hall.

[2]This kind of comprehensive policymaking is often called rationally comprehensive, synoptic, or rationalism. See, for example, Lindblom, Charles E. (1965) The Intelligence of Democracy. New York: Free Press; and Dye, Thomas R. (1972) Understanding Public Policy. Englewood Cliffs, N.J.: Prentice-Hall.

Consequently, the interdisciplinary team has to narrow the scope of the analysis to what it decides are significant problems and issues and feasible alternative policies and implementation strategies. The team employs the general interdisciplinary team procedures described above to accomplish this narrowing, applying criteria and standards to be identified and described in the following sections.

5.3.1 Identifying and Defining Significant Problems and Issues

Problems and issues are introduced into the TA from two sources. First, some are introduced from external sources, for example, as a consequence of energy development already in operation, being constructed, or being proposed.[1] Others are identified as a part of the TA itself. Problems and issues from both sources arise as a consequence of impacts. Therefore, the identification of problems and issues begins with an examination of impacts. To determine which impacts and/or combinations of impacts are expected to raise significant problems and issues, the team will take into account such considerations as:[2]

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[1]The team has found a number of environmental impact statements private and public funded scientific and technical programs, congressional hearings and committee reports, and a variety of materials useful as external sources of information on impacts, problems, and issues. A list of some of these is presented in Appendix C.

[2]Additional criteria and standards will be added when gaps are identified. Obviously, not all criteria and standards apply to all impacts.

1. Knowledge--what is the state of knowledge? degree of uncertainty?

2. Magnitude--how large will the impact be? can it be defined?

3. Timing--phasing? When will the impact begin?

4. Reversibility--can the impact be reversed?

5. Distribution--will the impact be confined or widespread?

6. Legal standards--will the impact violate existing local, state, federal regulations; or an international agreement?

7. Social equity--will the impact affect all classes and ethnic and religious groups the same?

8. Social values--will the impact be socially acceptable? Will life-styles be changes?

9. Political--will the impact be amenable to political accommodations? for example, will it be possible to negotiate acceptable tradeoffs, compromises, etc.?

10. Health effects--will the impact affect human health?

11. Synergistic effects--will the impact combine with other impacts or existing conditions to produce new impacts?

12. Uniqueness--will the impact eliminate unique plant or animal communities or scenic or historical areas, etc.?

13. Material and equipment--will the impact overload producers, slowing delivery dates and driving up prices?

14. Aesthetics--will the impact change skylines, be noisy, etc.?

15. National goals--will the impacts adversely affect other national goals, such as national security, etc.?

16. Economic and financial--will the impact increase costs, intensify the competition for capital, etc.?

17. Precedent setting--has the impact been experienced before?

On the basis of the results obtained from this examination, the team can identify the problems and issues that it considers to be significant. As is the case at each step in the policy analysis, both internal and external review will be conducted to insure that significant problems and issues are not overlooked. In addition, an attempt will be made to determine whether changes in state of society assumptions and the consideration of certain exogenous forces, for example, a pricing policy change by the Organization of Petroleum Exporting Countries (OPEC), would materially alter the composition of the list.

Having compiled a list of problems and issues that appear to be significant, the research team proceeds to define them as clearly as possible in terms of the standards and criteria used to establish their significance. This process includes identifying the interests and values likely to be affected by the impact. In particular, it includes identifying potential interest and value conflicts that policymakers should be aware of when they choose their policy response.

It is also important in defining the problem or issue to identify the policymaking forums within which solutions might be worked out; and the functional relationships among these institutions need to be identified and understood. Given the scope of the western energy TA, local, state, Indian, regional, and national governmental and intergovernmental institutions will be emphasized. However, nongovernmental actors often play key roles in problem solving and policymaking and the team will take care to insure that these actors are taken into account.

The research team begins its policy analyses with the understanding that:

1. procedures, processes, participants, and forums will vary from issue to issue;

2. some problems will be more important to some participants than to others;

3. some solutions are more likely to be arrived at outside government;

4. some problems fall within more than one jurisdiction;

5. some problems can be resolved by only one level of government; and

6. what is perceived to be a problem at the national level may not be considered a problem at the local, state, or regional level.

All of these factors must be taken into account and, where appropriate, included in the definition of problems and issues.

5.3.2 Identifying and Describing Feasible Policy Alternatives and Implementation Strategies

The second step in policy analysis is to identify the options available to policymakers for responding to significant problems and issues. Again, the interdisciplinary team follows the general procedures described in Section 5.2. At this stage of the analysis, three things have to be considered. What can be done to eliminate, reduce, or enhance an impact, solve a problem, or resolve an issue? What are the appropriate governmental and nongovernmental, formal and informal political institutions and structures (policymaking forums) within which the problems and issues should be addressed?[1] And what strategies can be used for implementing the policies produced by these political institutions and structures? In examining these considerations, the team will determine when there are barriers or constraints which eliminate some alternatives, policymaking forums, or implementation strategies from further consideration.

The team will use a preliminary list of ten categories of barriers and constraints in making a determination of which alternatives are feasible. These categories and an example within each category are listed below:

1. Legal: Communities bearing the impacts might require energy developers to prepay their taxes as a means for obtaining the capital needed to finance social infrastructure expansion. However, in most states, the law does not provide for this option.

2. Economic: Energy facilities to be located in areas where air quality has not been deteriorated might be required to meet more stringent air quality standards than now exist. However, the added dollar costs may make it so uneconomical that it rules out development.

3. Technological: Given the same situation described in number 2 above, the technological capability may not be available--regardless of cost.

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[1]The examination of policymaking forums also requires a determination of jurisdictions, institutional and legal barriers, and past performance records.

4. Institutional: Problems such as air and water quality resulting from a proposed development may require regional solutions. However, there may be no regional intergovernmental organization with authority to act. Moreover, it is very difficult to establish such organization.

5. Physical: Exporting coal as a raw resource rather than as a fuel may be viewed within the region as a much preferred option. However, construction of the required transportation capability such as locomotives, trucks, hopper cars, racks, pipe, etc., may exceed production capacity and the availability of physical resources.

6. Environmental: Given the same situation as in number 5, the export of coal either as a solid or synthetic fuel to a demand center such as Chicago, may result in severe environmental problems for Chicago. These may be so severe as to be unacceptable.

7. Social: Siting a new energy facility in a favorable location with regard to an energy resource, water, railroad, etc., may result in significant alterations in existing life-styles.

8. Cultural: Given the same situation as in number 7, the development may be unacceptable to some Indians because the activity would violate their cultural values.

9. Political: Viewed from a national perspective, it might be considered environmentally desirable to export electricity or synthetic gas, rather than coal from a proposed development. However, this may be unacceptable to the people living in that state and they may organize to make it politically infeasible.

10. Jurisdictional: An energy facility located in one state may produce undesirable air quality problems in an adjacent state. The receiving state has no jurisdiction. Federal or regional jurisdiction might be proposed, but this might be viewed as undesirable even by the state receiving the impacts.

Needless to say, these categories are neither mutually exclusive nor exhaustive. However, when employed using the interdisciplinary team approach and review procedures, they should provide for a reasonably comprehensive evaluation of the feasibility of alternative policies and implementation strategies. Those which are considered feasible are then evaluated; those that are not are not discarded until consideration is given to what would be required to make them feasible, for example, state of society changes or some significant exogenous intervention.

5.3.3 Determining Costs, Risks, and Benefits

Following the identification and description of feasible alternatives, the costs, risks, and benefits that each would produce are determined. In developing western energy resources, the assumed goal is to maximize positive values or benefits. Ideally, negative impacts or costs would be avoided altogether![1] Likewise, risks such as the exposure of ecosystems and human populations to harmful impacts would also be avoided. In practice, all choices produce combinations of costs, risks, and benefits. The analytical goal to be achieved by the research is to be able to indicate what these combinations will be, taking into account the fact that one person's benefit may be another person's cost. The team also recognizes that this evaluation of alternatives will not elminate uncertainty about the consequences that can be anticipated when a particular policy alternative and implementation strategy is chosen.

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[1] On these points, see Quade, E.J. (1975) <u>Analysis for Public Decisions</u>. New York: American Elsevier.

Initially developed as an analysis technique by economists, cost/benefit analysis is now used extensively in applied policy research, including TA.[1] When narrowly applied, the analyst assigns monetary values to each impact and adds up the pluses and minuses to identify the alternative likely to produce the highest net benefit.[2] In TA, this analytical approach employs a broader range of values than dollars.

A variety of measures is used to determine costs, risks, and benefits because some impacts cannot be meaningfully expressed in dollar terms; others cannot be expressed in any single measure. For example, birds killed in an oil spill or human lives lost in a coal mine cave-in cannot be readily valued in dollar terms. Some of the costs sustained in an oil spill or mine cave-in can be meaningfully expressed in dollar terms--clean up, rescue operations, lost production time, and so forth. But birds and human life have in addition, an intrinsic value that cannot be captured using this measure. In fact, to reduce costs of this kind to dollars is to

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[1]For a discussion of the cost/benefit approach to evaluation, see Rothberg, Jerome (1975) "Cost-Benefit Analysis: A Methodological Exposition," in Marcia Guttentag and Elmer L. Struening (eds.) Handbook of Evaluation Research, vol. 2. Beverly Hills, Calif.: Sage Publications, pp. 55-88.

[2]For a discussion of some of the pitfalls of this approach, see Hanke, Steve H., and Richard A. Walker (1975) "Benefit-Cost Analysis Reconsidered: An Evaluation of the Mid-State Project," in Richard Zeckhauser and others. Benefit-Cost and Policy Analysis, 1974. Chicago: Aldine. See also Roback, Herbert (1972) "Politics and Expertise in Policy Making," in National Academy of Engineering, Committee on Public Engineering Policy. Perspectives on Benefit-Risk Decision Making. Washington: National Academy of Engineering, pp. 121-133.

do policymakers a disservice. Likewise, it is a disservice to express losses of this kind in any single measure. The significant analytical point for policy analysis is that multiple quantitative and qualitative measures are required to describe costs, risks, and benefits, their scope, and how they are distributed.

In the case of birds, for example, it is not so much the number of birds killed--although that is probably a better single measure than dollars would be--it is considerations such as: Is the impact likely to be reversible or irreversible, short-term or long-term, and so forth. If the birds killed are a large percentage of the extant whooping crane population, for example, the loss is much more significant, than would be a much larger loss of a nonendangered species such as starlings or English sparrows. Such distinctions are important to policymakers, most of whom operate within guidelines which tell them a short-term impact is more acceptable than one that is long-term; that a reversible impact is preferable to an irreversible one; that impacts adversely affecting few persons while benefiting many are preferable to those producing the opposite results; and so forth. Consequently, in order to best serve policymakers, the policy analysis results of this TA will be reported using the combination of impact measures which best express costs and benefits in terms of the range of values and interests which are at stake. An attempt will also be made to take into account the perspectives of policymakers at different levels and in different branches of government, as well as the perspectives of individuals and groups who do not share common interests and values.

The principal criteria and measures to be used in expressing the costs, risks, and benefits of alternatives are: [1]

1. Economic measures can apply to many areas, including industrial, agricultural, recreational, labor, business, and governmental sectors. The attempt here is to quantify costs and benefits of feasible alternatives in monetary terms. This allows for the development of ratios or other measures of the extent to which costs exceed returns, or vice versa. Two important ways of measuring economic costs and benefits are:

    a. Direct and indirect monetary measures: The economic costs of an alternative can be expressed in dollars. These can be measured by market valuations or for nonmarket items by imputation (shadow pricing). For example, process engineering changes such as environmental control devices, or removing land from agricultural production can be assessed in financial terms. Likewise, externalities or spillover costs and benefits can be similarly measured. For example, if a town downstream from an industrial plant is forced to treat water that has been degraded by the plant, the costs imposed on the municipality are fairly easy to identify and measure.

    b. Distributive measures: Policy alternatives may distribute costs and benefits evenly or unevenly, The point here is whether some groups in society will be benefited more than other groups. For example, at the local level, the installation of a power plant in a community will increase its tax base even though workers at the plant may come from an adjacent larger community which will not receive that tax benefit. At an aggregate level, cost benefit

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[1] These criteria are closely related to both the impact analysis categories used in Chapter 4 and the standards and criteria introduced in this chapter. At this stage of the policy analysis, the emphasis is on alternatives for addressing impacts. It should not be surprising that the evaluation of impacts and alternatives involves the use of similar currencies.

distribution can be represented by income measures for a group or region. The distribution of income for a region can be represented graphically by a Lorenz curve which shows the degree of inequality in the distribution (summarized by the Gini ratio of income concentration). Additional information such as median income per capita, and the skewness of income distribution may be included to further assess the distributive effects of policy alternatives on groups.

2. Resource Availability and Consumption. The demands created by an alternative can be measured against supplies of energy, water, or other materials and equipment categories. Measures for these include:

   a. Net energy: Alternatives can be evaluated in terms of energy input (as Btu's or calories) required to produce a given energy output, or this can be expressed as an efficiency.

   b. Physical measures of materials or equipment: The demands created by an alternative can be described as tons of steel, gallons of water, or other such factors. These units can also be expressed as proportions of nonrenewable resources that are depleted, or proportions of scarce water supply used. Economic measures described above may also be applied to some of these factors.

3. Space and Time Requirements. The range of an alternative effect can be expressed in both spatial and temporal terms. The alternative may resolve only the local problem, for example, or it may eliminate the impact entirely. Alternatives may also provide either short-term or long-term solutions.

4. Environmental and Ecological. The effects on natural systems from alternative policies can be expressed through a number of categories. These include, for example:

   a. Air quality: Pollutant impact can be assessed in terms of miles of reduced air visibility, smell, or deposition of particles.

   b. Water and land: Policies may affect availability of land acreage, acre-feet of potable water, etc.

c. Biota: Policies may preserve a number of rare species or maintain carrying capacity for herds of big game.

5. Health and Safety. Policies may affect the exposure of humans working at a facility or outside the fence lines. These occupational and public effects can be measured over both the short- and long-term, for example:

   a. Disease incidence: The incidence of specific diseases can be assessed in terms of illness per hundred thousand individuals.

   b. Injuries and deaths: Rate of death and injuries can be estimated in terms of days lost, or morbidity and mortality statistics experienced in alternative occupations and the general population.

6. Social Structure. Policy alternatives can be measured in terms of a variety of quantitative and qualitative effect on social, political, and cultural patterns, behavior, and institutional arrangements. These include:

   a. Social indicators: Developed indicators can be used when they exist. For example, population influxes can change age and sex demographic distributions, the availability and quality of schooling (measured as per capita education expenditures), recreational opportunities (measured by visitor-days to indicate the relative attractiveness of hunting, camping, and hiking areas), and other aspects considered to be components of social well-being or quality of life. In cases where indicators either are inadequate or have not been developed (for example, in the areas of aesthetics, life-style changes, and so forth), costs and benefits due to changes in these amenities, services, or attitudes can be described qualitatively.

   b. Political: Alternative policies can be evaluated in terms of their responsiveness to parties-at-interest; and policymaking procedures can be evaluated in terms of provisions for public participation. For example, local decisionmakers who may dominate the political jurisdiction under consideration may have enough of a political base to render an option infeasible. That is, one criteria for assessment will be their related ability to mobilize support. Economic measures described above may also be applied to some governmental factors, for example, costs for additional administrative, personnel, public welfare services, or added service capacity for sewers, highways, development planning, etc.

As with the other steps in policy analysis, this list is not intended to be exhaustive; nor are the listed criteria thought to be mutually exclusive. They overlap greatly; and for each the basic questions concerning certainty (state of knowledge), scope, duration, distribution, and the introduction of exogenous forces and changes in state of society assumptions have to be raised. The basis for much of this evaluation of alternatives will be products of the ERDS, scenarios, impact analyses, and problem and issue identification and definition. This step, the evaluation of alternatives, is, therefore, largely a summarizing and organizing activity. That is, the products produced by these earlier tasks provide a basis for evaluating alternative policies and implementation strategies. At this stage in the analysis, the emphasis is on systematically stating what the costs, risks, and benefits are expected to be given the operational definitions and assumptions the team is using.

5.3.4 Identifying the Alternative with the Highest Net Value Expectation and Making Recommendations

Once they have been evaluated, alternatives can be compared in terms of their costs, risks, and benefits. The analytical ideal would be to produce a single rank-ordering of alternatives. This, of course, is why expressing all costs, risks, and benefits in a single measurement unit is so appealing. If this could be done satisfactorily, choices might be more obvious. However, as long as value and interest conflicts persist, policymakers are charged with the responsibility of choosing from among alternatives which distribute a range of values and interests differently. Consequently, to be politically useful, comparisons of the costs, risks, and benefits of alternatives should be expressed in that combination of measurement units which most appropriately indicates how the various alternatives being considered distribute the values and interests that are at stake. Instead of a single list, this results in several lists, each of which can be rank-ordered on the basis of a single measure, interest, or value. For example, alternatives may be rank-ordered separately on the basis of their direct and indirect economic costs, energy costs, consumption of water and consequences for existing life-styles. This provides the policymaker and other interested parties quantitative and qualitative bases for making their choices, presumably with a better understanding of the tradeoffs and accommodations that will be required and the extent of the uncertainty involved.

Based on the results of its comparative evaluation of alternative policies and implementation alternatives, the team will at least in some cases, make recommendations. In doing so, choices will be justified in terms of specific values and interests. This will include an identification of the constraints (assumed or exogenously specified) that were applied, an indication of the levels of uncertainty involved, and, an identification of the impacts that were anticipated and the relative importance assigned to them.

In recommending implementation strategies, the team will indicate which level, branch, agency, etc., of government or other organization should take action, the action that is required, and the chronology of actions that should be followed.

In making recommendations, the use of external, prepublication reviews by potentially impacted policymakers is vital, since frequently changes in only phrasing or terminology can be interpreted in substantially different ways, and it is important that the substance of a recommendation not be blocked by use of an inappropriate or disquieting term.

5.4 ANTICIPATED RESULTS

Anticipated results have been discussed throughout this chapter, particularly with regard to what the results will include and how they will be presented. The emphasis in policy analysis in the first year will be on the federal government, environmental policies, and the short- to mid-term future. How these results will be presented to the range of audiences that the team is addressing is discussed in Chapter 8.

5.5 DATA AVAILABILITY

Policy analysis is limited by the availability of information on a number of factors, including systematic identification and description of parties-at-interest and the various issues and problems perceived to influence the feasibility of policy recommendations. In part, this limitation on data availability is a reason for the conceptual approach that utilized comprehensive internal and external review procedures. Despite limitations in the published literature, we believe that an overall description of the factors influencing policy for energy development in the western U.S. can be obtained from both formal and informal data sources.

Only limited data are available to adequately perform cost, risk, benefit, and net energy analyses. Information on costs is available for a number of categories but, as discussed above, valuation of many factors will be difficult to perform and little published information is available, for example, in applying costs to air pollution damages.

Data for net energy analysis are widely available in a number of categories, such as for thermodynamic losses of both physical and selected biological processes, but detailed data for specific sites will have to be inferred from similar localities in many instances.

5.6 RESEARCH ADEQUACY

"Policy analysis represents the most critical challenge to TA because the most comprehensive and scientific data gathering and data manipulation is of little value to the policymaker unless it has relevant and cogent policy implications."[1] What is needed

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[1]Arnstein, Sherry R., and Alexander N. Christakis (1975) "Assessors' Perspectives on Policy Analysis," in Sherry N. Arnstein and Alexander N. Christakis, eds. Perspectives on Technology Assessment. Columbus, Ohio: Academy for Contemporary Problems.

to meet this challenge is a better understanding of how to produce and effectively present policy useful results. In short, what is required is an emphasis on applied interdisciplinary policy research. But, much of the research being conducted under the rubric policy analysis, public policy research, etc., is disciplinary in character and aimed almost exclusively at theory-building. Moreover, much of the limited applied policy research that is being conducted is aimed at developing single measures for combining costs, risks, and benefits. As indicated above, better tools for combining and comparing costs, risks, and benefits are needed; however, the single measure approach is likely to be counter-productive. Consequently, more emphasis should be given to developing a better set of measures.

CHAPTER 6

RESEARCH ADEQUACY, DATA AVAILABILITY, AND SENSITIVITY ANALYSES

6.1 INTRODUCTION

A report describing the adequacy of current research programs to support an assessment of western energy resource development is among the reporting requirements specified by the Environmental Protection Agency (EPA) for this project. This report is to compare the requirements for models, analytical techniques, data, and forecasts with the research goals and objectives that have been identified for the technology assessment (TA). A special effort will be made to identify areas where research might be undertaken and results produced in time to improve the quality of the second and third year TA reports.

Some data and research inadequacies have been described in preceding sections. In this section of the work plan report, we will describe the methods and procedures to be used to determine research requirements needed to support this TA.

6.2 PROCEDURES

Determining data and research adequacy consists of several tasks operationally inseparable from other elements of the TA.

As shown in Figure 6-1, these tasks include: (1) gathering and organizing the information and data base; (2) assessing information and data quality and hardness and, where possible, performing sensitivity and parametric analyses; (3) identifying research needs; and (4) defining research and data requirements. Major elements of these tasks are essential inputs into both the data adequacy report and the TA report itself, including a specification of the adequacy and quality of data and models. These tasks combine to form the data-gathering and evaluation process that is shown in Figure 6-2. This should be viewed as being an iterative process that continually responds to specific data and information needs.

6.3 INFORMATION AND DATA BASE

The initial phases of research adequacy consist of specifying the TA's information and data requirements and gathering and organizing the information and data base. Some specific data requirements for this TA have been defined in previous chapters. As indicated there, major sources include generally:

1. Direct contact with EPA, its laboratories, and sponsored research programs;
2. Direct contact with federal and state agencies which are conducting relevant research;[1]

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[1] There are several major efforts presently underway to identify ongoing energy-related research and development in the West. These include: a joint project by the Old West Regional Commission and Surface Environment and Mining (SEAM) program called "The Energy Research Information System"; a project being coordinated through the Western Governors Regional Energy Office; and a project at the Los Alamos Scientific Laboratory (LASL).

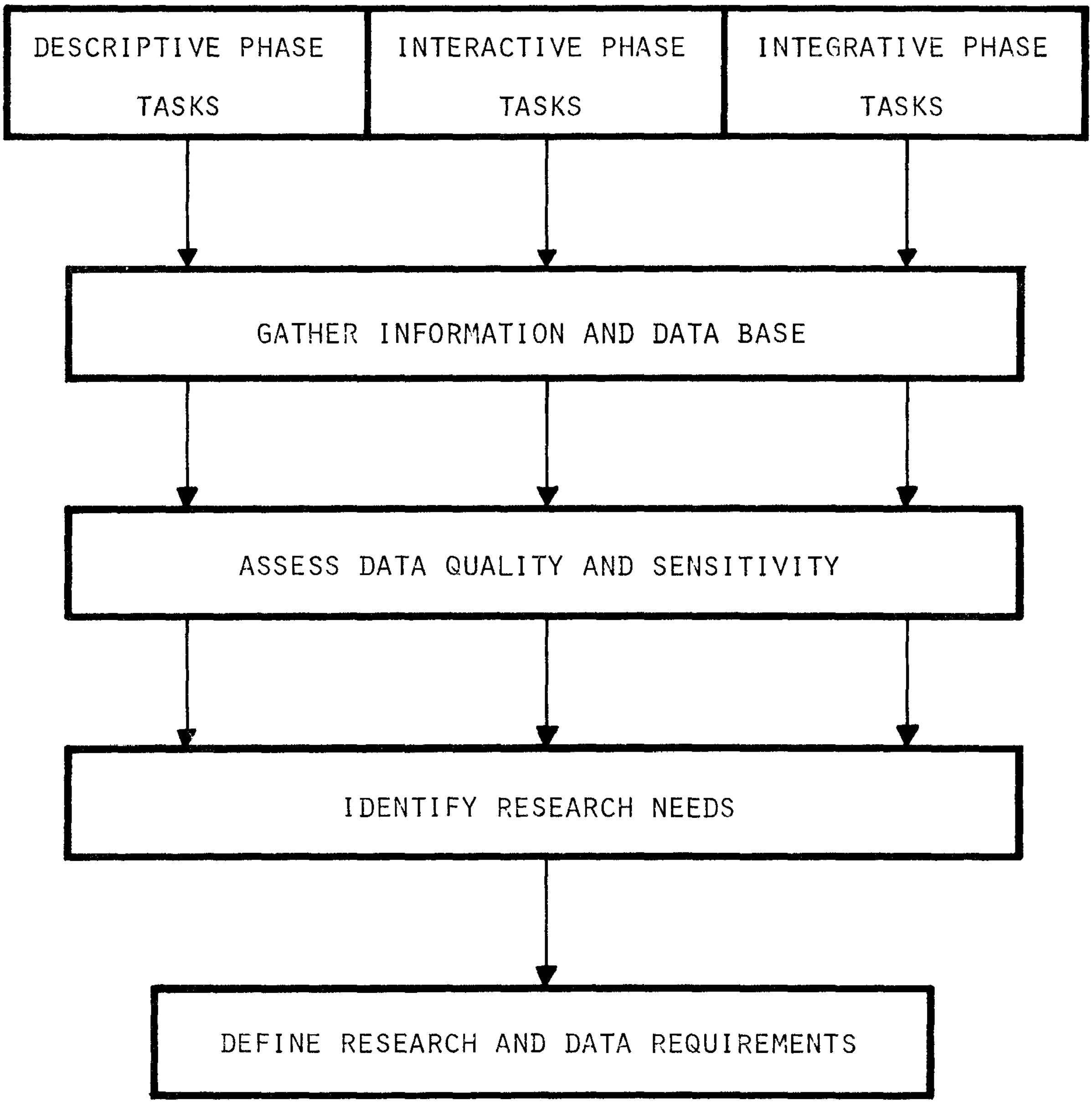

Figure 6-1: Overview of the Data Availability and Research Adequacy Task

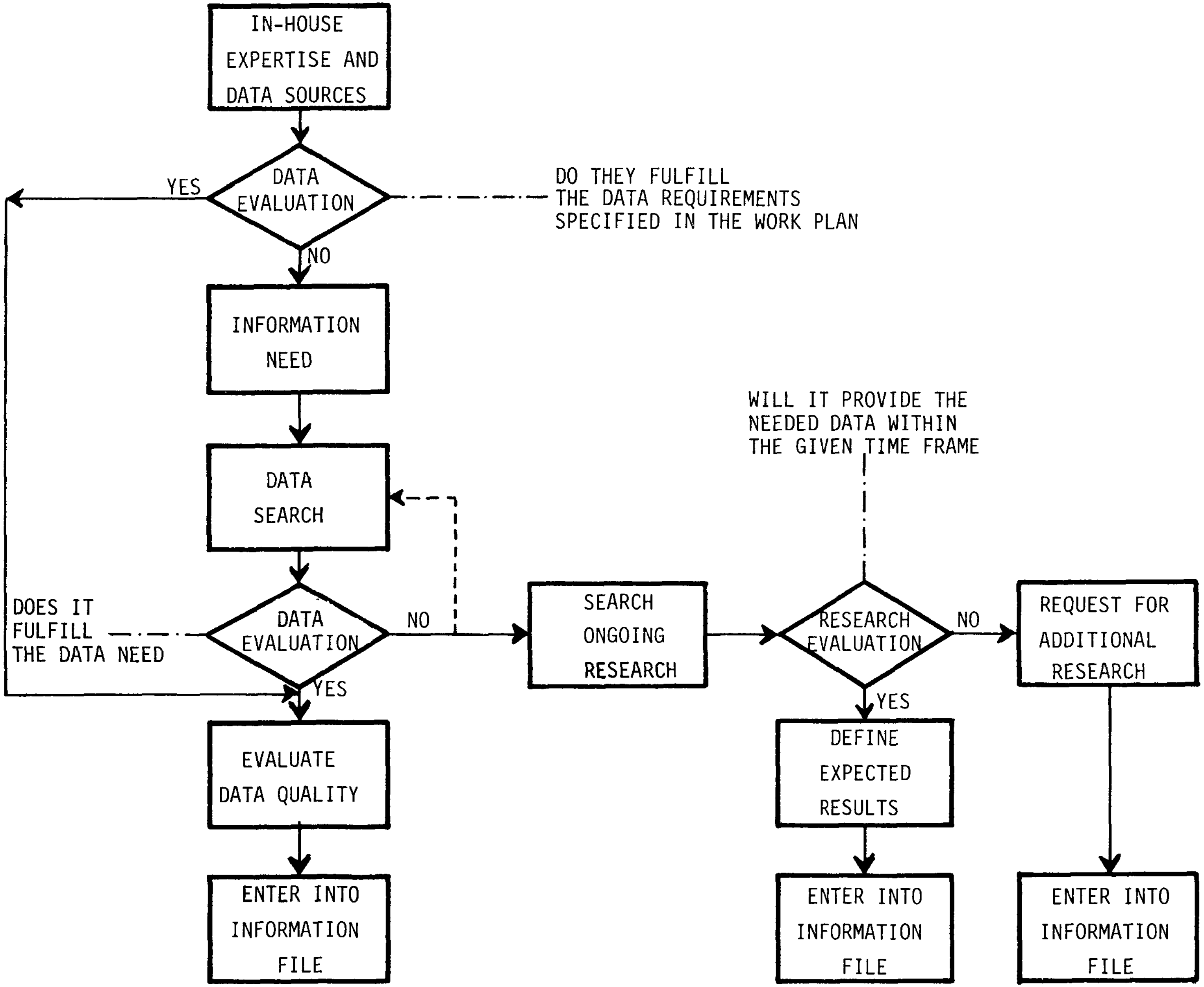

Figure 6-2: Specific Data Search Routine

3. Direct contact with relevant private research programs;[2]

4. Contractual and on-line computerized search services (for example, Technology Application Center, Smithsonian Science Information Exchange, Systems Development Corporation, and the Lockheed Dialog System);

5. Systematically reviewing periodicals, newsletters, and newspapers from the western states.

In the interest of integration with other research programs, information collection will include direct personal contacts with other researchers. This is intended to insure that we are aware of the most current information available (since bibliographies and computerized data bases may have backlogs of a year or more). No single source will be all inclusive and combinations of sources will have to be used.

The information described above is being entered into information and data files at both S&PP and Radian. As reports are acquired, they are abstracted and indexed with key words;

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[1]For example, Atomic Energy Commission, Oak Ridge National Laboratory (1974) Inventory of Current Energy Research and Development. Washington: Government Printing Office, 3 vols.; Environmental Protection Agency, Office of Research and Development (1975) Indexed Bibliography of Office of Research and Development Reports Updated to January 1975. Washington: Government Printing Office.

an example of key word headings is shown in Table 6-1. In addition, team members with primary responsibility for a particular task are compiling lists of data sources and needs in a form compatible with the centralized information and data file.

6.4 ASSESSMENT OF DATA QUALITY AND SENSITIVITY

The assessment of data quality is being conducted primarily by investigators responsible for specific analytical tasks. All team members have a responsibility for assessing the quality of data, and in instances where the sensitivity of the analysis to particular data is high, the primary assessment is reviewed by other members of the research team. General comments or specific reports on the quality of data are systematically incorporporated into the overall information and data system. General survey reports are assessed primarily in terms of the adequacy of their documentation, while technical reports, models, or engineering documents are evaluated on the basis of their assumptions, methodology, and data base. Although the quality of some data can be described quantitatively in terms of a likely range of error, much of the data must be evaluated qualitatively.

Sensitivity and parametric analyses are analytical tools which will be utilized, when possible, in the evaluation of data adequacy. Both techniques are used to estimate the effects of changes in either initial assumptions or discrete and continuous

TABLE 6-1: SECTION OF KEYWORD LIST FOR WESTERN ENERGY TA DATA FILE[1]

Compression
Consol Synthetic Fuel Process
    BT Coal liquefaction - hydrogenation
Cooling
Cooling lakes
    UF Cooling ponds
Cooling ponds
    Use Cooling lakes
Cooling towers
Cooling water
Core drilling
    RT Exploratory drilling
Corrosion mechanisms
Cost-benefit analysis
Costeam process
Cracking processes
Crude oil
    NT demetallation
        desulfurization
        development
            Use production
        exploration
            NT regulations
        pipelines
        production
            UF development
                well completion
            NT drilling
                    NT economics
                        regulations
                field processing
                    UF Field processing - crude oil
                improved recovery
        refining
            UF Petroleum refining
            NT product transportation
                refinery siting
                regulations
        reserves
        resources
        storage
        well completion
            Use production
Culm piles
    Use Coal mining - waste disposal

Demographic economics
Desulfurization
    UF Sulfur removal
    SN (may also be used as a subheading)

[1]This keyword list includes notation for the user so that subordinate terms can be related to other terms for cross referencing or to select more appropriate terms: BT = broader term; NT = narrower term; RT = related term; UF = used for; SN = scope note (qualifies as a term); Use = refer to (directs user to the correct terms).

input parameters on outputs and conclusions. When applied to analytic models, sensitivity and parametric analyses can provide the range of outcomes associated with variables of high uncertainty or identify variables which significantly affect conclusions. This indicates that these parameters should receive additional emphasis. Although this kind of analysis can be applied to both quantitative and qualitative analyses, they will be used primarily in conjunction with quantitative models.

6.5 IDENTIFICATION OF RESEARCH NEEDS

As the TA progresses, specific data needs within tasks are being identified. A major element of the research adequacy task will be the comparison of these data needs, with research being conducted on an in-house and extramural basis by federal and state agencies and private organizations. The results of this comparison will provide the basis of an integrated description of recommendations for further research in support of this study.

6.6 ANTICIPATED RESULTS

The primary product of the research adequacy effort in the first year will be the Research Adequacy Report. As noted earlier, the purpose of this report is twofold: first, to evaluate the ability of current research programs to support an assessment of western energy resource development; and second, to provide specific research recommendations in areas where the current research effort is found to be deficient.

The research adequacy effort will also provide support for the first year TA report by identifying uncertainties in the data and indicating sensitivities in the models used for impact and policy analyses. This will permit a realistic interpretation of the results in the report.

CHAPTER 7

PROPOSED PERFORMANCE SCHEDULE

7.1 INTRODUCTION

The performance schedule for the first year is organized to correspond to the four major reporting requirements for the first year: First Year Work Plan; Technology Assessment (TA) report; Research Adequacy; and Second and Third Year Work Plan. The schedule for each provides for internal reviews by the S&PP-Radian research team and external review by an advisory committee, consultants, selected representatives of parties-at-interest, the Western Energy Resource Development Sector Group, and the Environmental Protection Agency (EPA). Our objective is to expose draft reports to extensive reviews to insure that: (1) persons and organizations interested in western energy resource development have an opportunity to comment on and criticize the TA while it is being conducted; (2) factual information is accurate and the best that is available; (3) analyses are critically reviewed to identify biases and logical inconsistencies; and (4) a broad range of significant problems and issues likely to arise are analyzed. The dates for draft and final reports are those specified by the original contract or modifications to it. All other dates are best estimates and subject to change.

7.2 THE PERFORMANCE SCHEDULE FOR THE FIRST YEAR

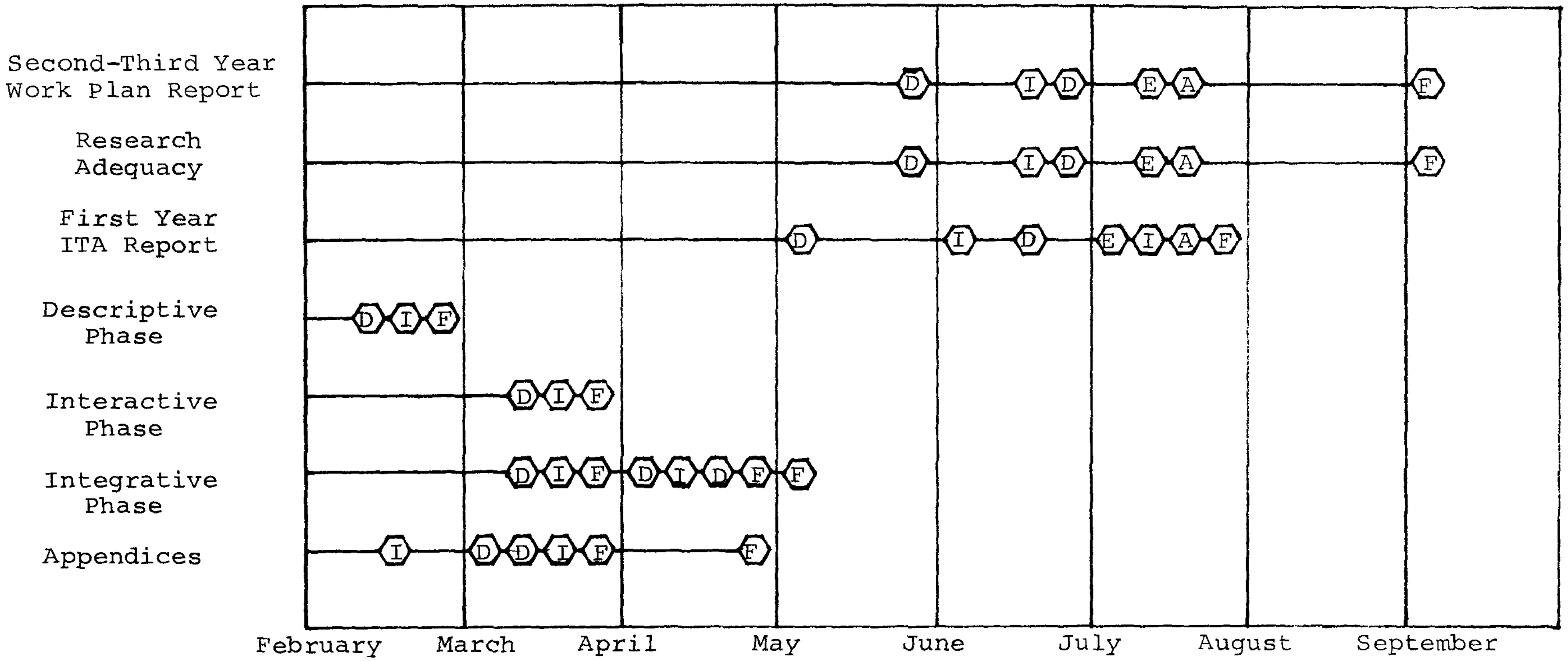
The schedules for the TA report, Research Adequacy, and the Second and Third Year Work Plan are outlined in the following subsections. This will be followed by a summary schedule of items of particular importance. This schedule is graphically presented in Figure 7-1.

7.2.1 First Year TA Report

The performance of the first year TA is actually an integration of the Descriptive, Interactive, and Integrative Phases (as presented in Section 2.2) plus the appendices. For this reason, the schedules of the three phases and the appendices precede the preparation of the first year TA report in the following presentation.

Descriptive Phase

Date	Task or Activity
February 16, 1976	Revise all site-specific descriptions
February 20	All aggregated descriptions due
February 23	Review all aggregated descriptions
February 25	Revise all aggregated descriptions



KEY
Draft Description Due = D
Final Description Due = F
Internal Review = I
External Review = E
Advisory Committee Review = A

Figure 7-1: Performance Schedule for Products During First Year

Interactive Phase

Date	Task or Activity
March 5, 1976	All first level analysis due
March 12	Review of all first level analysis
March 17	Revise all first level analysis

Integrative Phase

Date	Task or Activity
March 15, 1976	Illustrative impact analysis and initial policy analysis due
March 23	Exchange comments on illustrative impact analysis and policy analysis
March 27	Revise illustrative impact analysis and policy analysis
April 15	All second level analysis and final policy analysis due
April 21	Comment on all second level analysis due
April 26	Recommendations for implementation strategies
April 28	Revised second level analysis due
April 30	Comments on recommendations for implementation strategies due
May 5	Revised recommendations for implementation strategies due

Appendices to First Year TA

Date	Task or Activity
February 16, 1976	Radian's review draft regional overview description due
March 15	S&PP's revised draft of the regional overview description due
March 19	Radian's final draft of ERDS descriptions due
March 22-26	Revise draft of ERDS descriptions
March 26	ERDS descriptions complete
April 30	Regional overview complete

First Year TA Report

Date	Task or Activity
March 26, 1976	Outline of first year TA report due
April 2	Comments on outline due
May 7	Draft TA report due
May 10-28	Type draft TA report
June 4	Results of internal review due
June 18	Revise draft report due
June 18-July 5	Type revised draft report
July 6	Mail revised draft report to EPA and external reviewers
July 12-15	Internal S&PP-Radian review
July 16	Meet with Advisory Committee to review the revised draft report and the energy resource development systems description

Date	Task or Activity
July 18-30	Revise
August 2-20	Type final report
August 27	Final correction due
September 3	Mail final first year TA report

7.2.2 Research Adequacy Schedule

The information required for preparing this report has been and will continue to be collected as a part of all other research tasks being performed by team members. In addition, the librarians, research assistants, and person responsible for liaison with relevant research projects are systematically compiling information on research adequacy as described in Chapter 6. The schedule outlined here includes only tasks from the present to submission of the Research Adequacy report.

Date	Task or Activity
November 1, 1975 - May 14, 1976	Compilation of research adequacy information as indicated in Chapter 6 of work plan completed
May 14	S&PP-Radian exchange inputs
May 21	Comments due
May 28	Edited draft due
May 28-June 4	Type
June 11	Internal review due
June 18	Revised draft due

Date	Task or Activity
June 21-July 6	Type
July 7	Mail draft report to EPA and external reviewers
July 16	Internal review and meet with Advisory Committee
August 13	Comments from reviewers due
September 3	Revised draft due
September 17	Final corrections due; type final
September 24	Mail final

7.2.3 Schedule for the Second and Third Year Work Plan

Date	Task or Activity
May 14, 1976	S&PP-Radian exchange inputs
May 21	Comments due
May 28	Edited draft due
May 28-June 4	Type
June 11	Internal review due
June 18	Revised draft due
June 21-July 6	Type
July 7	Mail draft report to EPA and external reviewers
July 16	Internal review and meet with Advisory Committee
August 13	Comments from reviewers due

Date	Task or Activity
September 17	Final corrections due; type final
September 24	Mail final

7.2.4 Summary Schedule

The dates and tasks and activities listed below integrate some of the most important items from the four separate schedules.

Date	Task or Activity
July 6, 1976	Mail draft research adequacy report and draft second and third year work plan report to EPA and selected external reviewers
July 6	Mail revised first year TA report to EPA and external reviewers
July 15-16	Meet with Advisory Committee
September 3	Mail final first year TA report
September 24	Mail final research adequacy report and final second and third year work plan report

CHAPTER 8

REPORTING RESULTS OF THE FIRST YEAR TA

8.1 INTRODUCTION

The products to be produced by this technology assessment (TA) have been generally described either explicitly or implicitly in the preceding chapters. These research products are intended to meet the needs of the Environmental Protection Agency (EPA) and a broad range of the participants in the various policy systems included in the study. This chapter describes some of the major objectives for these products and how research results will be presented to achieve them.

8.2 BASELINE DATA COMPILATION

As noted in Chapter 3, our baseline data are being organized into a systematic format called energy resource development system (ERDS). These descriptions of energy resources, technological alternatives, and social controls can be extremely important in a number of ways. First, the technological descriptions included in the ERDS's are written to be understandable by nonengineers. As such, they can help to educate a broad range of interested, but technologically relatively uninformed participants. The S&PP-Radian team's past experiences suggest that the availability of these kinds of descriptions helps to raise the level of public debate over problems and issues which become matters of great national concern.

In addition, the ERDS descriptions are designed to facilitate the systematic comparison of energy alternatives. Except for the addition of sections on social controls, the format corresponds to the data and analyses standardized by the MERES (Matrix of Environmental Residuals for Energy Systems) system of the Council on Environmental Quality. These technological and social control descriptions will serve as a planning handbook for private individuals and groups, as well as local and state government officials and federal agencies. Given this systematic, standardized format, the ERDS will facilitate comparisons of the alternatives being evaluated, discussed, prepared, or otherwise considered.

An additional set of baseline data is contained in the Regional Description. The general information on the western U.S. contained therein helps the reader to understand the context in which western energy resources are being developed--and in which the TA will be conducted. Again, the team has a policy goal in mind: better informed public debate o problems and issues. This descriptive product should be of particular value to persons who are not familiar with the western U.S.

The scenarios also describe what is required in terms of time, materials, personnel, capital, etc., for representative energy developments to occur. These requirements differ by technology, by resource, and by location. Comparisons of requirements will both contribute local information and provide a representative overview of what is involved in energy development. Private individuals and government officials will be able to see clearly the overall scope of activity associated with development in a local area and in large regions.

8.3 ANALYTICAL RESULTS

The bulk of the TA report identifies impacts from energy development, as well as gaps in knowledge, data, and analytical tools. The impacts are assessed within the policy analysis framework, resulting in the identification of problems and issues, policymaking systems, trade-offs, and possible accommodations by concerned parties. The report will make underlying assumptions explicit, identify data and tool limitations, report costs and benefits using a variety of measures, and give an indication of which values and interests would be promoted by various alternatives. Finally, the report will include recommendations based on stated assumptions, which indicate which courses of action the team believes to be in the overall national interest, taking local and state interests into account.

8.4 RESEARCH ADEQUACY

As noted above, there is to be a separate report on research adequacy. This report is intended to assist the EPA's Office of Research and Development in evaluating the adequacy of its research program for supporting a TA of western energy development. The report will identify areas which limit the TA and will make specific recommendations for how these limitations might be overcome.

8.5 DISTRIBUTION OF RESULTS

The baseline data and the reports are to be made available to a large number of officials and individuals through widespread distribution of both draft and final versions. Presentation and interpretation of the TA report's findings and recommendations will be made public further through visits by the S&PP-Radian team to sites and government offices throughout the West during the second and third years.

As indicated in S&PP-Radian's proposal, the team believes that for a TA to be well-informed, credible, and useful, parties-at-interest, particularly potential users of the reported results, must be kept informed and involved from the outset of the assessment. Almost immediately after the contract was awarded, efforts were begun to make contact with the multiple parties-at-interest likely to be important to this study. Federal agencies, state governments, energy industries, intergovernmental organizations, energy and environmental researchers, and interest groups, were among those contacted. As the study has progressed, these contacts have broadened. Consequently, potential users of the report have already been involved and will continue to be. These potential users will have had an opportunity to contribute to the study by commenting on drafts, furnishing information and data, or in some other way. The report will thus be available to users already familiar with the work, and should be immediately usable. The effort of involving potential users will continue in the second and third years as subsequent reports are prepared.

In addition to the basic report, there will be an executive summary detailing major findings, policy issues, and recommendations providing easy access to the results of the TA for all interested individuals, groups, and governments. This will be designed to be distributed even more widely than the full TA report, so that other potential users can become familiar with the study by reading an abbreviated report of the first year's results.

CHAPTER 9

TENTATIVE PLANS FOR THE SECOND AND THIRD YEARS

9.1 INTRODUCTION

At the present time, detailed plans for the second and third years have not been formulated; however, the contract requires that three assessments be completed, the second and third to be iterations of the first and second; and the expectation is that each iteration will update, refine, improve, fill in gaps, and analyze in greater depth, impacts, problems, and issues which prove to be particularly significant. As indicated in Chapter 7, the reporting schedule now requires that the draft second and third year work plan report be submitted by September 24, 1976. This is after the first year Technology Assessment (TA) report will have been completed, and will permit members of the S&PP-Radian research team to benefit fully from the first year's assessment before committing themselves to a plan for the second and third years. However, formulating this work plan for the first year has required the team to think about the full three year effort. The tentative plans presented in this chapter are a product of that advanced planning.

9.2 OVERALL

As noted above, when available, new and better data will be used, as will new or improved analytical tools. The goal will be to update and upgrade the results of the first year TA as a basis for developing generalizations about the likely consequences of western energy development.

The identification of higher order impacts is also expected to receive increased emphasis during the second and third years. Greater emphasis will also be given to determining the sensitivity of results to particular assumptions and values in all impact categories.

A continuing effort will be made to review the state of society assumptions that the team made at the outset. Given the highly speculative nature of all forecasting, the team believes it to be essential that the treatment of these assumptions be carefully reviewed and revised at least annually.

The illustrative net energy analyses conducted during the first year will probably be extended; and additional analyses will be added if possible.

9.3 SCENARIOS

Technologies for developing all six resources will be monitored closely to insure that the alternatives included in the scenarios are realistic choices for the specified time periods.

Particular attention will be given to process modifications and new and improved environmental control technologies.

It is expected that additional site-specific scenarios will be developed to raise issues either not raised or not treated in depth during the first year. For example, it is expected that a geothermal scenario will be developed for either Thermo, Utah or the Salton Sea area of California, and the assessment of the nuclear fuel cycle might be expanded beyond the uranium milling stage, the limit established for the first year assessment of uranium technologies. Additional technological alternatives will also be added as new technical data become available from ongoing research. Possible technologies include, for example, low-Btu coal gasification coupled with on-site electricity generation, the use of fluidized-bed boilers, and in-situ coal gasification and in-situ oil shale retorting.

During the second and third years, the aggregated scenarios will receive more detailed attention. For example, a broader range of national issues resulting from western regional development will be analyzed. In part, this more detailed analysis might be possible because of refinements now being added to the Project Independence interfuel competition model. Another model which may be used to identify national impacts from western energy development is the Environmental Protection Agency's (EPA) Strategic Environmental Assessment Systems (SEAS). This model might be used to identify relationships such as the impact on various supply industries, for example, mining equipment, from various levels of western energy development; in addition, it could be a useful tool for forecasting regional energy demand.

9.4 IMPACT ANALYSIS

It is expected that all the categories of impact analysis will be revised and to some extent expanded as additional information becomes available during the second and third years. The qualitative studies of impacts attributed to air and water quality, and to socioeconomic conditions, have been identified as areas to receive more attention during the second and third years.

In air quality, several research projects currently underway are attempting to identify the chemical kinetics of sulfate and oxidant formation. As results from these projects become available, it is hoped that the team will be able to identify more precisely cause and effect relationships between these pollutants and their effects on man and the ecosystem.

In the first year analysis, water quality was described primarily in terms of salinity. In the second and third year effort, a more detailed analysis utilizing additional parameters will be conducted.

No new topics are expected to be added to the ecological task in the second and third years. However, certain topics, treated generally in the first year will receive more detailed attention. These may include:

1. Effects of human disturbance on wildlife. A concerted effort to obtain first-hand observations and case history data will not be possible until the second or third year.

2. Options for the protection and management of representative ecological systems (as opposed to individual species populations).

3. Impact of agricultural expansion during the remainder of the century.

4. Impacts of increased recreation pressure in specific ecologically sensitive areas, such as the wilderness areas of the White River National Forest in Colorado.

In the socioeconomic impact analysis, new employment multipliers may be estimated utilizing relatively new techniques which are more suitable for localities in rural areas than the presently available multipliers which are being used in the first year assessment. Also, the results of current studies which are monitoring the views of individuals affected by current development towards that development may be available in the second and third years. To complement these studies, the team plans to do more interviewing during visits to the western region.

Several important aspects of the health effects impact of energy development have been delayed until the second and third years of the study in anticipation (hope) that improved data from basic research will permit a more definitive treatment than is now possible. In addition, refinements of air quality predictions and the demographic aspects of the socioeconomic analysis during the second and third years will improve the basis for assessing indirect impacts to public health.

Topics tentatively scheduled for attention during this period include:

1. Impacts of "noncriteria" pollutants; for example: Trace elements and polynuclear aromatic compounds will be studied.
2. Occupational and public health implications of accidents.
3. Identification of particularly susceptible population subgroups and preliminary estimation of the frequency of pollution-related illness throughout entire populations.
4. Impacts of "urban plumes" on public health.
5. Implications for health care delivery of rapid population growth.

9.5 POLICY ANALYSIS

Policy analysis will receive major emphasis during the second and third years. Since it is at this stage in the TA that the results of everything else get integrated, policy analysis during the first year will necessarily have to focus primarily on the problems and issues identified before the TA got underway. During the second and third years, the analysis of these can be extended to take into account more nuances and subtleties; and the number of alternatives analyzed and compared can be extended. However, the first and second year TA's may also surface a number of unanticipated problems and issues, particularly as higher order consequences receive more and more attention. These will receive special attention.

Another aspect of policy analysis that will receive special attention during the second and third years is implementation strategies. One aspect of this will be to acquire a more in-depth knowledge of the relevant policymaking systems. This will include, for example, more detailed examination of both formal and informal structures and institutions, governmental and nongovernmental participants, authorities and jurisdictions, operating style and procedures, and past records and achievements. This in-depth knowledge will be a prerequisite to any really meaningful evaluation of implementation strategies.

At a more general level, the increased emphasis on policy analysis will be aimed at enhancing the credibility of the team's results by demonstrating to policymakers that the team has been sensitive to the range of values, interests, etc., that the policymakers have to concern themselves with in making hard choices. One means for doing this is to maintain continuous contact with the policymakers while the study is underway. These contacts have been initiated and will be extended during the first year, but the real basis for engaging the policymaker's attention will be the first year TA report. Consequently, policy analyses during the second and third years will intensify contact with individual policymakers and policymaking systems to get their reactions. This is essential to learning in more detail about their perceptions about what is important, their notions about alternatives and how to implement them, and their own interpretations of what constrains the options available to them.

APPENDIX A

PERSONS CONTRIBUTING TO THE DEVELOPMENT OF THE FIRST YEAR WORK PLAN

The following list of names includes consultants, persons who responded to a request for comments and suggestions on the "Draft First Year Work Plan Report," or who contributed in some other way to the development of this "First Year Work Plan."[1]

Adams, William, Environmental Monitoring and Support Laboratory, Las Vegas, NV

Allen, Wallace B., Pacific Gas & Electric Company, San Francisco, CA

Ancell, Kenneth L., Energy Conversion Development, Panhandle Eastern Pipe Line Company, Houston, TX

Anderson, Carl, Environmental Protection Department, Montana Power Company, Butte, MT

Anderson, Frederick R., Environmental Law Institute, Washington, DC

Annison, Michael H., Federation of Rocky Mountain States, Inc., Denver, CO

Anthony, James H., Intermountain Power Project, Sandy, UT

Babb, Malcolm C., Water Quality Branch, Tennessee Valley Authority, Chattanooga, TN

Baden, John, Dr., Department of Political Science, Utah State University, Logan, UT

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[1]We apologize for any inadvertent omissions.

Barch, Gene, Technology Application Center, University of New Mexico, Albuquerque, NM

Barnes, Mickey, Council of Advisors for State Government, Denver, CO

Barnett, Jack, Western States Water Council, Salt Lake City, UT

Bartlit, John R., New Mexico Citizens for Clean Air and Water, Los Alamos, NM

Baughman, Martin, Dr., Center for Energy Research, University of Texas, Austin, TX

Beezhold, Wendland, Montana MHD Project, Billings, MT

Bender, Lloyd, Economic Research Service, U.S. Department of Agriculture, Montana State University, Bozeman, MT

Bigler, Craig, State Planning Office, Salt Lake City, UT

Bishop, Bruce, Dr., Utah State University, Logan, UT

Boldt, Robert E., Federal Energy Administration, Region IX, San Francisco, CA

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APPENDIX B

AN OUTLINE OF THE OIL SHALE ENERGY RESOURCE DEVELOPMENT SYSTEM

As discussed in Chapter 3, an energy resource development system (ERDS) description is being prepared for each of the resources: coal, oil shale, oil, natural gas, uranium, and geothermal. Following is an outline of the ERDS description for oil shale.

OIL SHALE RESOURCE DEVELOPMENT SYSTEM

3. Union Retort
    a. Residuals
    b. Materials Requirements
    c. Manpower Requirements
    d. Economic Costs
    e. Energy Efficiencies
4. In-situ Retorting
    a. Residuals
    b. Materials Requirements
    c. Manpower Requirements
    d. Economic Costs
    e. Energy Efficiencies
5. Processing Social Controls

D. Reclamation
1. Technological Alternatives
    a. Residuals
    b. Materials Requirements
    c. Manpower Requirements
    d. Economic Costs
    e. Energy Consumption
2. Social Controls

E. Transportation
1. Pipelines
    a. Residuals
    b. Materials Requirements
    c. Manpower Requirements
    d. Economic Costs
    e. Energy Efficiencies
2. Social Controls

APPENDIX C

USEFUL EXTERNAL SOURCES ON IMPACTS, PROBLEMS, AND ISSUES

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GLOSSARY

Aggregated scenario--a scenario which postulates the development of energy resources at one or two specified levels within a large area such as that defined by a river basin or several states.

Aldehyde--any of various organic compounds containing a carbonyl group (CO) and a hydrocarbon group such as CH_3.

Anabatic circulation--an upslope wind resulting from local surface heating, rather than from the effects of the larger-scale circulation.

Ancillary energy--the amount of energy required from external sources to accomplish the activities required for energy resource development.

Ash--the residue left when combustible material is thoroughly burned or otherwise oxidized.

Baseline conditions--within an area to be studied, the prevailing state of such potentially impacted categories as air quality, water quality and quantity, solid waste, noise, land use, ecology, resource availability, economy, and social fabric and structure.

Basic stability windrose information--a bivariate frequency distribution depicting the frequency of occurrence of various wind speed/wind direction combinations as a function of one of the six Pasquill stability classes. A total of sixteen wind direction categories and six wind speed categories are in the distribution.

Bench scale--pertaining to a small, laboratory test of a process which precedes pilot plant testing.

Beneficiation--cleaning and minimal processing to remove major impurities or otherwise improve properties.

Biochemical oxygen demand (BOD)--the amount of oxygen required by bacteria to convert organic material into stable compounds.

Biome--a major ecological community type.

Btu (British thermal unit)--a measure of energy equivalent to the amount of heat required to raise the temperature of one pound of water one degree Fahrenheit.

Carbon monoxide (CO)--a pollutant resulting from incomplete combustion of fossil fuels.

Chemical oxygen demand (COD)--the amount of oxygen required to convert (oxidize) organic compounds into stable forms--usually carbon dioxide and water. COD includes all compounds requiring oxidation while BOD includes only the biodegradable fraction.

Chinook winds--warm, strong down-slope winds on the lee slopes of the Rocky Mountains which can cause flooding conditions.

Cooling tower drift--the airborne transport of salts which are a by-product of the use of evaporative towers to dissipate the heat from processes such as combustion of coal for electricity generation.

Cost/risk/benefit analysis--a technology assessment technique in which values are assigned to such concerns as social impacts in order to weigh the overall benefits and costs associated with recommended policy alternatives.

Dispersion model--a set of mathematical formulations used to describe the way in which airborne pollutants will be distributed around their source.

Dry (geothermal) site--a geothermal well which produces dry steam.

Dry steam--steam which is not mixed with a liquid water phase.

Dynamic meteorology--the study of atmospheric motions as solutions of the fundamental equations of hydrodynamics or other systems of equations appropriate to special situations.

Economic base model--a model which considers two employment sectors--basic or production for export and non-basic or production for local goods and services--to predict the impacts of exogenous changes on urban and regional economies.

Ecosystem--the interacting biological community and physical components that occur in a given area.

Ecosystem units--vegetation units and their associated fauna.

Elastic supply curve--supply of an input is variable with the price, indicating that enough of the input will be available when it is needed.

Energy resource development system (ERDS)--a way of conceptualizing the interrelation of the various factors relevant to the development of an energy source; it encompasses a resource, the technologies required to develop it, and the social controls that are imposed when these technologies are deployed.

Input-output model--a model which considers many sectors of an economy and the interrelationships among them to describe an economy and to predict the impacts from exogenous changes.

In-situ--in the natural or original position; applied to energy resources when they are processed in the location where they were originally deposited.

Integrated technology assessment--see technology assessment.

Inversion frequencies--the percentage of time that there is present in a region a layer of the atmosphere through which the temperature increases as a function of increasing height (thus inhibiting vertical motions).

Katabatic circulation--any wind blowing down an incline. If the wind is warm, it is called a foehn or chinook; if cold, it is usually a gravity wind in which cold, dense air drains to lower elevations.

L_d--daytime equivalent sound level.

L_{dn}--day-night equivalent sound level.

L_{eq}--the long-term equivalent of A-weighted sound levels.

L_n--nighttime equivalent sound level.

Lead time--the time needed for planning, financing and construction of required facilities before they are ready for use.

Low-Btu gas--gas obtained by partial combustion of coal with air; energy content is usually 100 to 200 Btu's per cubic foot.

Lurgi high-Btu gasification--a medium pressure process using a rotating grate reactor with steam and oxygen to produce medium Btu gas which is then upgraded in a methanation step.

Milling--a process in the uranium fuel cycle where ore which contains only .2 percent uranium oxide (U_3O_8) is converted into a compound called yellowcake which contains 80 to 83 percent U_3O_8.

Mixing depth--the height above the surface to which vertical mixing and a neutral lapse rate (no change in air temperature with increasing height) occur because of mechanical turbulence and/or surface heating.

Multiplier--the quantity which measures the effects (direct, indirect, or induced) of a given change in a local or regional economy.

Net energy analysis--the amount of energy that remains after the energy costs of finding, producing, upgrading, and delivering the energy have been paid.

Net primary production--the amount of energy available from plants; an indicator of ecosystem function and capacity.

Nitrates--class of secondary pollutants that includes acid-nitrates and neutral metallic nitrates.

Nitrogen oxides (NO_x)--class of primary pollutants that includes nitrogen oxide (NO) and nitrogen dioxide (NO_2).

Overburden--the rock, soil, etc., covering a mineral to be mined.

Oxidants--a class of secondary pollutants some of which are formed by photochemical processes.

Ozone--an oxidant formed in atmospheric photochemical reactions.

Particulates--microscopic pieces of solids which emanate from a range of sources and are the most widespread of all substances that are usually considered air pollutants. Those between 1 and 10 microns are most numerous in the atmosphere, stemming from mechanical processes and including industrial dusts, ash, etc.

Parties-at-interest--individuals, groups or organizations (such as local residents, Indian tribes, industry, labor, or various levels of government) whose interests or values are likely to be affected by the development of western energy resources.

Pasquill stability classes--a system of classifying stability on an hourly basis for research in air pollution; uses a matrix relating net radiation and surface wind speed (the primary determinants of stability near the ground).

Peroxyacyl nitrates (PAN)--organic compound formed in smog atmospheres that is believed to be one source of characteristic eye irritation accompanying smog.

Pilot plant scale--pertaining to a test of a process at 1/100 to 1/10 of commercial size.

Primary efficiency--the ratio between the energy value of the output fuel and the energy value of the input fuel.

Regional scenario--the largest aggregated scenario, comprising the eight-state Rocky Mountain and Northern Great Plains region; the states included are: Montana, North Dakota, South Dakota, Wyoming, Colorado, Utah, Arizona, and New Mexico.

Residuals--the quantities of inputs to, and non-energy outputs of the technological processes involved in energy resource development.

Scenario--a projected course of actions or events; a mechanism for identifying and assessing the likely consequences of hypothetical patterns of development.

Site-specific scenario--a scenario which postulates the development of one or more energy resources at a particular site over specified time periods using a particular combination of technologies.

Social controls--formal (such as administrative and regulatory) and informal (such as interest-group) sanctions relating to the various phases of energy resource development.

Socioeconomic impacts--changes in population, economy, culture, and other economic and social conditions resulting from an exogenous change in an area.

Slurry pipeline--a pipeline through which coal--in the form of a mixture of water and coal--is transported.

Stability class distribution--the frequency of occurrence associated with each of the six Pasquill stability classes on a monthly, seasonal, or annual basis at a particular location.

Sulfates--class of secondary pollutants that includes acid-sulfates and neutral metallic sulfates.

Sulfur dioxide (SO_2)--one of several forms of sulfur in the air; an air pollutant generated principally from combustion of fuels that contain sulfur.

Synoptic meteorology--the use of meteorological data obtained simultaneously over a wide area for the purpose of presenting a comprehensive and nearly instantaneous picture of the state of the atmosphere.

Synoptic-scale flow--circulations having the scale of the migratory high and low pressure systems of the lower troposphere, with horizontal dimensions on the order of 1000 to 2500 kilometers.

Synthane high-Btu gasification--a fluidized bed, high pressure reactor process using steam and oxygen. Distinguished by the high methane yield in the initial reaction process.

Synthoil liquefaction--a high pressure, high temperature process which makes a liquid hydrocarbon from coal by adding hydrogen to the coal using a catalyst.

Technology assessment (or integrated technology assessment)--an examination--generally based on previously completed research rather than initiating new primary research--of the second- and higher-order consequences of technological innovation. TA attempts to balance these consequences against first-order benefits by identifying and analyzing alternative policies and implementation strategies so that the process of coping with scientific invention can occur in conjunction with, rather than after, such invention.

TOSCO II process--a retort for producing a liquid hydrocarbon from oil shale by heating the shale in a reducing atmosphere using externally heated solid pellets as the heat source.

Total dissolved solids (TDS)--dissolved mineral salts generally consisting of sodium, calcium, magnesium, sulfate, chloride, and bicarbonate ions.

Transport modeling--method of predicting ambient concentrations (both in air and water) of pollutants emitted from a source or combination of sources.

Transport wind field--the set of ambient wind directions and speeds input to a transport model.

Trend projection methods--prediction based on the assumption that past trends will continue to hold in the future.

Wet steam--a two-phase steam consisting of steam and water.

Yellowcake--the product of the milling process in the uranium fuel cycle; it contains 80 to 83 percent uranium oxide (U_3O_8).

KEYWORD LIST

Coal
Oil shale
Crude oil
Natural gas
Uranium
Geothermal energy
Government policies
Environmental impacts
Socioeconomic impacts
Water resources
Esthetics
Economic analysis
Land use
Electric power generation
Electric power transmission
Electric power
Gasification
Liquefaction

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16. ABSTRACT

This report presents a Work Plan for conducting a Technology Assessment of energy resource development in the Western U.S. The energy resources addressed are coal, oil shale, oil, natural gas, geothermal, and uranium. The geographical focus is on the States of North and South Dakota, Montana, Wyoming, Utah, New Mexico, Arizona and Colorado. The time frame to be addressed is the period 1975-2000. The Assessment is designed to identify and quantify the diverse impacts of energy development in the West, including secondary or higher order impacts. Further, the Assessment will identify and assess policy alternatives for dealing with these impacts, with a special focus on environmental protection strategies. Nine scenarios are used to structure the analysis. Six of these are site-specific: Kaiparowits/Escalante, Navajo (Farmington), Rifle, Gillette, Colstrip, and Beulah. Two are river basins: the Upper Colorado and the Upper Missouri. And one is comprised of the eight states within which much of the six energy resources are concentrated.

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